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THE
ELI WHITNEY FOREST

A DEMONSTRATION OF FORESTRY PRACTICE

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NEW HAVEN: YALE UNIVERSITY

1930

95

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FOREWORD

This publication has been prepared as a contribution toward solving some of the forestry problems with which owners of woodland are confronted. Forest conditions and details and methods of forest management on one property, the Eli Whitney Forest, are set forth here in the hope that the recital may provide a helpful object lesson.

Forest management is scarcely initiated in the United States. On most forest tracts it is either not practiced at all or else is in the early stages of organization. Thousands of landowners should begin such work on their own holdings. The biggest task to-day confronting those who wish to conserve our forest resources consists of getting private owners started in forest management and in creating, among the people who do not own forest land, a sympathetic understanding of the situation. For this reason the attempt has been made to present what has been accomplished on the Eli Whitney Forest in a way that is interesting not only to the forester but, what is more important, to the private owner of forest property.

Illustrations have been used freely in order to bring before the reader the character of the forest and the operations which are carried on. With the exception of the frontispiece all illustrations have been placed at the end of the text, and appropriate references are made throughout the text to individual plates. The illustrations are arranged so as to advance progressively with the text and are accompanied by full descriptions which often give additional details. The photographs were taken especially for this bulletin by P. J. Meyer, of the Simonds Commercial Photo Company.

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THE ELI WHITNEY FOREST

INTRODUCTION

The territory within which the Eli Whitney Forest lies is representative of the oak region of Connecticut, New Jersey, and southeastern New York. It is representative not only in respect to general forest conditions and climate but also economic and social conditions.

The property is owned by the New Haven Water Company, a private corporation supplying water to the city of New Haven, Connecticut, and to the surrounding territory. It is the largest private holding in a region where private holdings of small size are characteristic. The municipal water boards and private water companies in the region usually own forest land adjacent to their reservoirs. Forest land so owned, however, forms only a small proportion of the total forest area of the region. The large size of the Eli Whitney Forest and the strength and permanence of its ownership make it an excellent demonstration forest, capable of furnishing a variety of object lessons in forestry applicable on tracts of various sizes. Forestry problems of the large and of the small owner are in principle essentially the same, though details of solution may vary with the individual tract.

A special value of the Eli Whitney Forest as a demonstration area arises from the relatively long time during which forestry has been applied. Small portions have been under management since 1900, while a large part of the property has been under management since 1907. A period of 20 to 30 years is relatively short, as viewed in the light of the total time required to grow a crop of trees from seed to maturity. These few years, however, represent virtually the entire span of the practice of forestry in America. This tract has been under sustained yield management for a longer period than any other forest tract in America known to the authors.

The New Haven Water Company was organized in 1849. At first relatively small areas of land other than reservoir sites were acquired. Purchases of land began on a large scale after 1900. Buying has been especially rapid during the last eight years. During this period the holdings have approximately doubled in size and now comprise over 20,000 acres of land exclusive of water surfaces. The map opposite page 14 shows the location of the lands, all of which lie within a 19-mile radius from the center of New Haven.

In Table I, approximate figures for the areas owned, exclusive of water surfaces, are given for each of the ten watershed divisions into which the Eli Whitney Forest is divided.

Soon after the establishment of the Yale School of Forestry in 1900, the necessity developed for finding forest lands near the city of New Haven upon which to conduct field work and research. It was found that many of the most accessible and best timbered tracts were owned by the New Haven Water Company. In 1901 arrangements were made with this company whereby the wooded lands on a single tract of about 250 acres near the Maltby Lakes were placed under the management of the Yale School of Forestry. In the autumn of 1907 the New Haven Water Company decided to practice forestry on their entire holdings, which then comprised over 8,000 acres. With this idea in view the coöperative arrangement with the Yale School of Forestry was extended to all the company's lands. Professor Ralph C. Hawley, as the representative of the Yale School of Forestry, was appointed forester for the New Haven Water Company.

TABLE I. AREA OF ELI WHITNEY FOREST BY WATERSHEDS

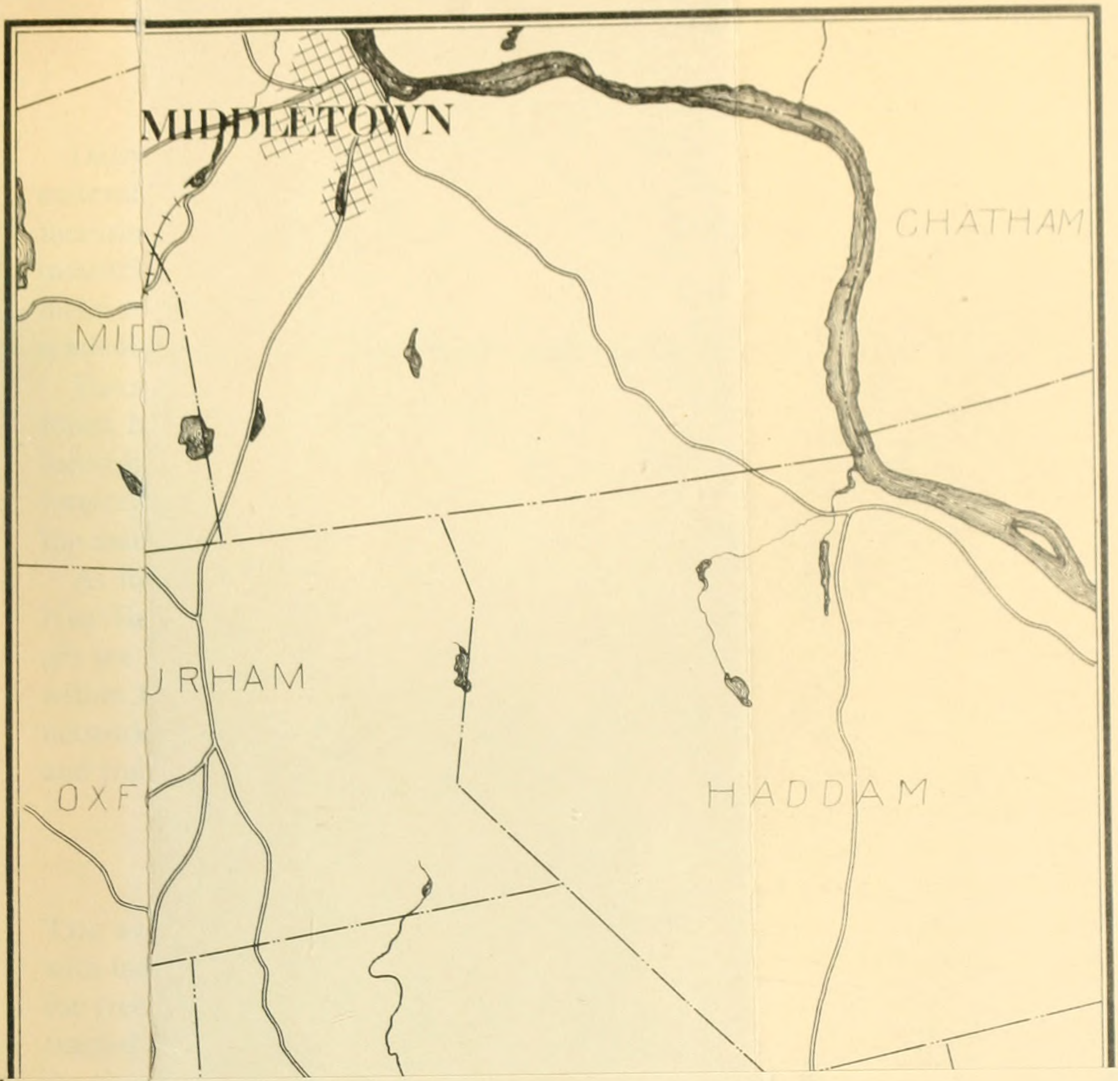
Division	*Area in acres*
Branford	625
East Wallingford	675
Maltby	1,365
Milford	245
Mill River	670
North Branford	10,500
Prospect	490
Saltonstall	1,375
West River	4,010
Wintergreen	590
Total	20,545

The coöperative arrangement, which is still in force between the Water Company and the School of Forestry, has proved of mutual advantage. The condition of the woodlands has improved and their protective value as a cover to the watersheds has been enhanced. As the forest develops under scientific treatment, its value as a demonstration area rapidly increases. The success attained in the forestry project has been due in large measure to the interest and active coöperation of Edward E. Minor, Yale 1896 S., general manager of the New Haven Water Company.

Recognizing the advantages of a distinctive title, the New Haven Water Company selected in 1929 the name "Eli Whitney Forest" as the special designation by which the forest properties should be known in the future. Eli Whitney, Yale 1869, after whom the forest is named, was president of the New Haven Water Company for many years and a member of the Corporation of Yale University from 1901 to 1919. He initiated the policy of land purchases and adopted the practice of forestry as the best use of the watershed areas.

INDUSTRIAL AND SOCIAL BACKGROUND

New Haven County, Connecticut, was colonized by the English nearly three hundred years ago. The region was at that time densely forested. Clearing for agricultural use gradually reduced the area of forest, until about 1820 the low point was reached. The forest then occupied approximately 25 per cent of the land area. Development of the better agricultural lands in the Central States and other changes in economic conditions have in the last 60 years made agriculture unprofitable on thousands of acres in Connecticut. The result has been a decrease in the use of such lands for agriculture, their reversion to forest, and a consequent increase in the forested area. This is still in progress. Approximately 50 per cent of the land area is now in forest. There appears little likelihood that the forested area will again be decreased by clearing for agricultural use, as the best lands are already farmed.


MIDDLETOWN
CHATHAM
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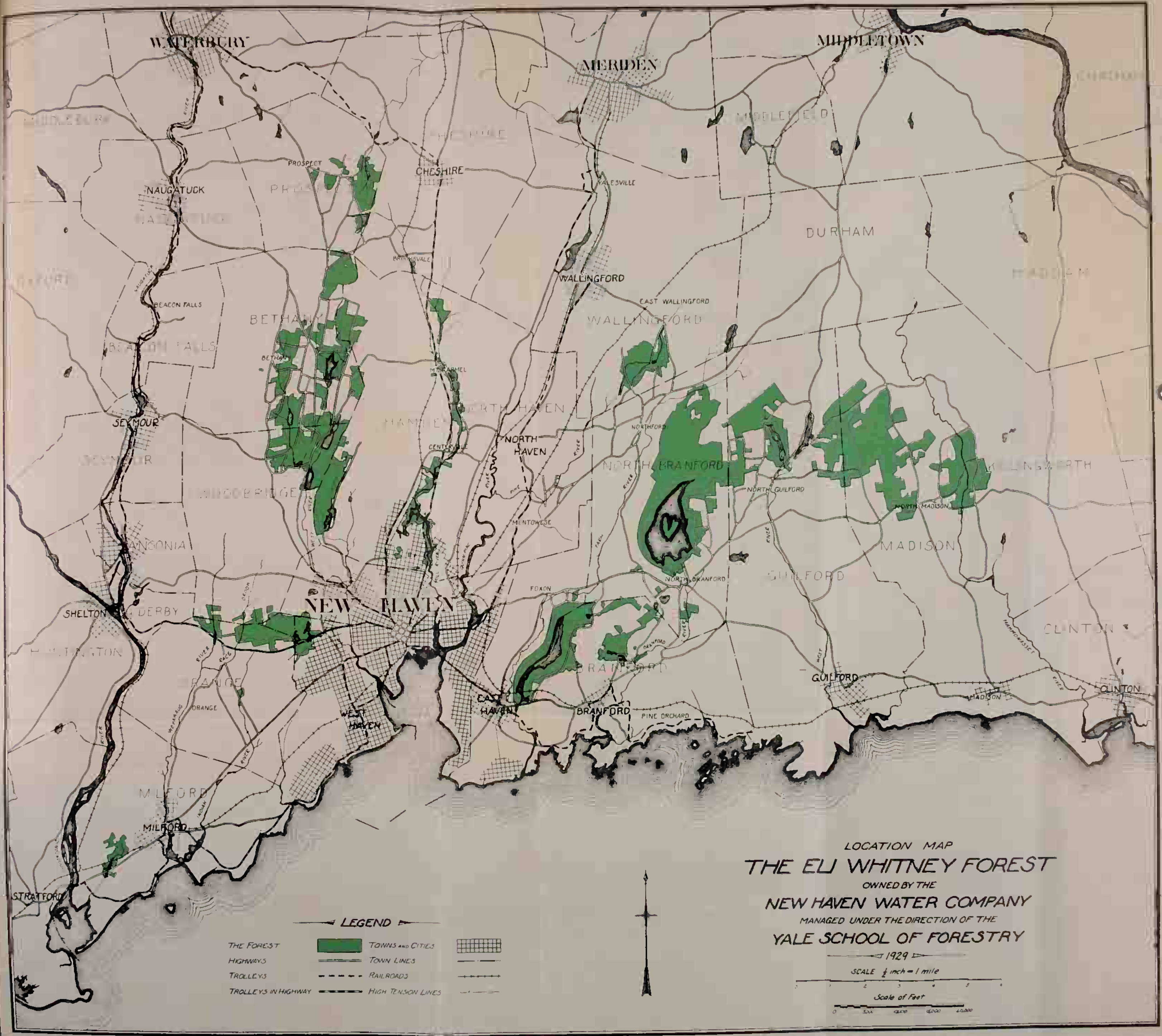
HADDAM



WATERBURY
MIDDLETOWN
MERIDEN
MIDDLEBURY
CHESHIRE
MIDDLEFIELD
CROMWELL
PROSPECT
CHESHIRE
NAUGATUCK
PROSPECT
NAUGATUCK
YALESVILLE
DURHAM
BROOKSVALE
WALLINGFORD
OXFORD
HADDAM
BEACON FALLS
EAST WALLINGFORD
BETHANY
WALLINGFORD
BEACON FALLS
BETHANY
MT. CARMEL
HAMDEN
NORTH HAVEN
SEYMOUR
NORTH HAVEN
NORTHFORD
SEYMOUR
CENTERVILLE
NORTH BRANFORD
KILLINGWORTH
NORTH GUILFORD
WOODBRIDGE
NORTH MADISON
MONTOWESE
ANSONIA
MADISON
GUILFORD
NORTH BRANFORD
FOXON
NEW HAVEN
SHELTON
DERBY
CLINTON
HUNTINGTON
BRANFORD
ORANGE
ORANGE
GUILFORD
EAST HAVEN
WEST HAVEN
BRANFORD
PINE ORCHARD
MADISON
CLINTON
MILFORD
MILFORD
STRATFORD
RIVER
NAUGATUCK
WEST RIVER
MILL RIVER
QUINNIPIAC RIVER
FARM RIVER
BRANFORD RIVER
WEST RIVER
HAMMONASSET RIVER
WEPAWAUG RIVER
INDIAN RIVER
LEGEND
THE FOREST 🟩
TOWNS AND CITIES ▦
HIGHWAYS
TOWN LINES
TROLLEYS
RAILROADS
TROLLEYS IN HIGHWAY
HIGH TENSION LINES
SCALE ½ inch = 1 mile
0 1 2 3 4 5 6
Scale of Feet
0 500 1000 1500 2000

LOCATION MAP

THE ELI WHITNEY FOREST

OWNED BY THE

NEW HAVEN WATER COMPANY

MANAGED UNDER THE DIRECTION OF THE

YALE SCHOOL OF FORESTRY

1929

Dairy and poultry farming, market gardening, and orcharding are the more important agricultural pursuits. All agricultural interests combined are subordinated in importance to manufacturing. In common with Connecticut as a whole, the New Haven region is primarily an industrial center. A wide range of products are manufactured, with those connected with the metal trades leading. The manufacturing industries use wood in a variety of forms, usually as a minor raw material, for containers or for repairs to plant.

Forest industries are not in themselves a large factor industrially. Past overcutting of the forest has reduced the present stand of merchantable timber to a low point and has forced forest industries to move elsewhere. Eventually forest industries will revive as the practice of forestry increases the available supply of raw material, but they will always be subordinate to the manufacturing of other products.

As indicated by the map opposite page 14, the Eli Whitney Forest surrounds the city of New Haven and is in turn surrounded by a circle of towns and cities. More than 400,000 people are living within ten miles of some portion of the forest. This population is concentrated within the towns and cities, leaving many parts of the country districts sparsely settled. A network of public highways, many of which are hard-surfaced, together with several railroad and trolley lines, provide excellent transportation facilities.

PHYSIOGRAPHIC FEATURES

The average annual precipitation at New Haven for the last 56 years has been 46.2 inches, with maximum and minimum of 60.3 and 34.8 inches, respectively. While the rainfall is ample for tree growth, droughts are likely to occur during the growing season and, while not protracted enough to seriously affect established forests, often cause considerable loss to reproduction and are especially disastrous to young plantations. During the past 56 years, on the average, the last killing frost in the spring has occurred on April 16, and the earliest in the autumn, on October 23; hence a growing season of at least six months may be relied upon.

Snowfall is light and cannot be depended upon as an aid in logging operations. Some years there is practically none of lasting nature. The occasional year is featured by snow a foot or more in depth which may stay on the ground for several weeks.

The range in elevation above sea level is from about 20 feet to approximately 700 feet, although the greater part of the land lies between 100 and 500 feet, and on any given tract the range in relative elevation is small. Drainage is toward Long Island Sound. Several of the streams converge as they approach the coast so that they pass either through the city of New Haven or near-by to the east or west.

Underlying the region and influencing its topography are three general types of rock; namely, sandstone, granites and schists, and trap rock. The sandstone, being the softest, has worn away most rapidly and presents a gently rolling topography which makes logging easy. Only a relatively small portion of the tract is of this character. Granites and schists which underlie the greater portion of the area are responsible for considerable minor irregularities, such as small knolls, ridges, or ledges rising abruptly to a height of from ten to one hundred feet above the hollows. Such topography, although not rough enough to interfere seriously with logging, often makes it difficult to get wood down from the higher elevations. Trap rock occurs occasionally in the form of dykes, sometimes rising over 200 feet above the surrounding country and frequently being precipitous on the north and west sides. Such ridges form the most striking topographic features and offer the greatest difficulties to the removal of timber. There is less trap than either of the other two rock types.

The soils as well as the topography have an intimate relation with the underlying rock. Judged by their ability to produce crops of trees, a variety of soils occur, varying from those in swamps too wet to permit tree growth to others on rocky ledges too dry and shallow to produce anything but scattered, stunted trees. There is a wide range of more productive sites between these extremes. Practically no infertile, sandy lands occur, since all of the soils, regardless of the underlying rock, are fertile enough for tree growth. The shallowest soils are on the trap ridges, but where of sufficient depth the trap soils are of excellent quality. The soils underlaid by sandstone are the least stony and contain considerable amounts of fine material with excellent moisture-holding capacity. On the average they are excellent agricultural soils. For this reason the proportion forested is lowest on areas underlaid with sandstone.

LAND CLASSIFICATION

In planning systematically for the management of large areas of land, one of the first steps is to separate the land into various types. This calls for a logical scheme of classification based usually on the purpose for which the land can be used and the character of the existing vegetation.

Ten land classes have been recognized on the Eli Whitney Forest. They are listed and defined below. Later on, under Forest Types, the forested land classes are discussed in more detail.

Agricultural. Lands actually used for cultivated crops, meadow, orchard, or pasture are included. An exception occurs in the case of pastured lands which are not clear but are partially stocked with bushes or scattered trees. Such areas are classified as old field.

Old field. This type includes lands formerly used for agriculture on which the process of reversion to forest is in progress but is not yet completed. A partial forest cover consisting principally of red cedar and gray birch is found on many old fields. Others which have been recently used for agriculture are covered with grass and weeds or are stocked with patches of brush.

Hardwood. Comprises upland forested areas occupied by broad-leaved tree species.

Hemlock-hardwood. Lands forested with a mixture of hemlock and various hardwoods are listed in this type.

Pine. Includes all forested areas which are composed 80 per cent or more of pine. Such stands are found principally as plantations. Plantations of arborvitae, balsam fir, Douglas fir, eastern hemlock, European larch, Japanese red pine, Scotch pine, western yellow pine, Norway, red, and white spruces are included in the pine type. The total area occupied by these miscellaneous plantations is small.

Hardwood swamp. This type comprises the stands of broad-leaved species which are growing on swamp land.

Cedar swamp. In a few instances swamps stocked with southern white cedar are found.

Open swamp. Swamps which do not support tree growth are classed under this heading. Most of these areas are permanently treeless due to excessive moisture. A few open swamps are capable of supporting a forest and will eventually reproduce to hardwoods and be transferred to the hardwood type.

Administrative. Certain open areas, chiefly near the lakes, dams, and gatehouses, are included here because of use in connection with the administration of the tract. Buildings, other than farm buildings, and surrounding lands used for residential purposes are placed in this class.

Barren. Occasional small areas of upland, useless for growing tree crops because of bare talus slope or exposed ledge rock, are classified as barren areas.

A tabular presentation of the areas in each land class is shown in Table II. This is not complete for the entire property but will indicate the relative importance of the various land classes. Until land buying is completed and the boundary surveys and mapping of the forest cover finished, Table II cannot be brought entirely up to date. It is estimated that at the present time approximately 1,800 acres more are owned but not mapped.

TABLE II. AREA OF ELI WHITNEY FOREST BY LAND CLASSES

Land class	*Area in acres*
Agricultural	1,464
Old field	988
Hardwood	12,676
Hemlock-hardwood	333
Pine	2,242
Hardwood swamp	609
Cedar swamp	59
Open swamp	237
Administrative	104
Barren	4
Total	18,716

FOREST TYPES

Six among the ten land classes are forested (though in the case of old fields only partially) and may be termed forest types. Three of these types, the old field, hardwood, and hemlock-hardwood, grow on upland (i.e. well-drained) soils and represent various stages in the development of natural forest on such soils. The pine type, while also situated on the upland soils, is of different composition and origin, being chiefly planted pine. Swamp (ill-drained) forest falls into either hardwood swamp or cedar swamp. The latter is rarely encountered.

In general the forest consists of young and middle-aged hardwoods. The distribution of the forest according to broad age classes in each forest type is shown in Table III. This brings out clearly the fact that the forest is relatively young. Approximately 1,800 acres have not yet been mapped.

TABLE III. AREA IN ACRES OF THE FOREST TYPES BY AGE CLASSES

Age in years	*Old field*	*Hardwood*	*Hemlock-hardwood*	*Pine*	*Hardwood swamp*	*Cedar swamp*	*Totals*
1-20		3,496.0		2,189.6*	95.0		5,780.6
21-40		4,838.0	4.5	52.3	78.7	27.4	5,000.9
41-60		1,836.9	32.7		241.7		2,111.3
61-80		518.6	10.4		126.6		655.6
81-100		36.4	33.1		65.4	31.8	166.7
Unevenaged	988.2	1,950.4	251.9		2.0		3,192.5
Totals	988.2	12,676.3	332.6	2,241.9	609.4	59.2	16,907.6

* Divided into 825.7 acres 1-10 years and 1,363.9 acres 11-20 years.

The principal commercial hardwood species are the red, white, black, and chestnut oaks. The original forest was cut long ago and no remnants remain. Indeed, most of the areas have been cut over several times since the region was settled. Clear cutting was practiced on a large majority of the holdings before they were acquired by the New Haven Water Company. Consequently, regular evenaged stands are characteristic of the present forest, although there are some exceptions, particularly on more inaccessible locations. In such situations only the saw timber may have been cut, leaving the smaller trees to grow. Unevenaged stands have resulted from this style of cutting. During the last twenty years a number of unevenaged stands have been developed by selection cuttings.

Twenty years ago chestnut was the most important tree before the chestnut blight exterminated the species commercially. Since chestnut formed a large per cent of the merchantable volume, its death resulted in disturbing the evenaged form of many stands or left them only partially stocked. Where the chestnut occurred in clumps, the openings were large enough to become stocked with a new crop of seedlings. In other cases the oaks and other hardwoods, stimulated by the openings, increased their growth and eventually took all the space which the chestnut had occupied.

A list of the native tree species occurring in the forest, with their common and scientific names, will be found in Table IV. Throughout the text the common names are used. Some of the species mentioned, such as paper birch and southern white cedar, are of rare occurrence.

Each of the six forest types will be discussed separately.

TABLE IV. TREE SPECIES IN THE ELI WHITNEY FOREST

Common name	*Scientific name*
Black ash	*Fraxinus nigra*
White ash	*Fraxinus americana*
Large-toothed aspen	*Populus grandidentata*
Basswood	*Tilia glabra*
Beech	*Fagus grandifolia*
Blue beech	*Carpinus caroliniana*
Black birch	*Betula lenta*
Gray birch	*Betula populifolia*
Paper birch	*Betula papyrifera*
Yellow birch	*Betula lutea*
Butternut	*Juglans cinerea*
Red cedar	*Juniperus virginiana*
Southern white cedar	*Chamaecyparis thyoides*
Black cherry	*Prunus serotina*
Choke cherry	*Prunus virginiana*
Chestnut	*Castanea dentata*
Dogwood	*Cornus florida*
White elm	*Ulmus americana*
Hemlock	*Tsuga canadensis*
Bitternut hickory	*Carya cordiformis*
Mockernut hickory	*Carya alba*
Pignut hickory	*Carya glabra*
Shagbark hickory	*Carya ovata*
Ironwood	*Ostrya virginiana*
Red maple	*Acer rubrum*
Sugar maple	*Acer saccharum*
Black oak	*Quercus velutina*
Chestnut oak	*Quercus montana*
Pin oak	*Quercus palustris*
Red oak	*Quercus borealis var. maxima*
Scarlet oak	*Quercus coccinea*
Swamp white oak	*Quercus bicolor*
White oak	*Quercus alba*
Pepperidge	*Nyssa sylvatica*
Red pine	*Pinus resinosa*
White pine	*Pinus strobus*
Sassafras	*Sassafras officinale*
Shad bush	*Amelanchier spp.*
Sycamore	*Platanus occidentalis*
Whitewood	*Liriodendron tulipifera*

OLD FIELD TYPE

When agricultural use ceases on open lands, whether they be cultivated, meadow, orchard, or pasture, these areas revert by natural seeding to forest. The process normally is slow and may require in some cases many years to obtain a complete forest cover.[1] Occasionally a cultivated field is fully stocked with trees within a year or two after cultivation is stopped. Red cedar, gray birch, and maple are the tree species which usually come in first. Following or accompanying these trees are individuals of all the other species native to the upland soils. With the trees, and sometimes preceding them, a variety of shrubs often start. Eventually the brush is replaced by trees, but the process of establishing a forest cover is delayed when shrubs come in first.

While an old field is in process of reversion to forest, it may present a picturesque appearance with grass areas interspersed with patches of brush and scattered trees (Plates 1 and 12). Old fields are unproductive until a fairly complete forest canopy is secured. All stages of development will be found, from old fields chiefly in grass up to those where the forest cover is practically complete (Plates 2, 3, and 4).

HARDWOOD TYPE

The hardwood type is distinguished from the other upland forest types by its composition, which consists principally of broad-leaved trees (Plate 5). More than 20 species are represented. Five oaks—red, black, scarlet, white, and chestnut—predominate, with hickories, maples, white ash, black birch, and many other hardwoods represented in varying proportions. On the poorest sites the oaks and the hickories form nearly the whole forest. On the best sites the mixture of species is more complicated and the oaks are relatively less important (Plates 6 and 7).

It is well recognized that the composition of a forest is subject to continuous change, until finally a stable combination of species is established. By "stable combination" is meant such a mixture of species as can maintain itself permanently, replacing the trees which die by others of the same species. The old field type already described is not a stable combination, since the gray birch is short-lived and the red cedar and shrubs grow slowly in height. Eventually the old fields change over to the hardwood type by the seeding in of oaks and various other hardwoods. Only a small proportion of the forest in the hardwood type originated by such natural conversion from the old field type. Most of the area in the hardwood type has always been forested. Stands of the hardwood type originate through natural seeding supplemented by stump sprouts. The sprouts do not predominate over the seedlings except on certain dry sites or unless the preceding stand was harvested when relatively young. Trees of sprout origin are much less important in the hardwood type than appearances in young stands sometimes indicate.[2]

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[1] For a comprehensive discussion of the progressive development of natural stands from the original bare fields on toward the final mixtures of hemlock and hardwood, see Lutz, H. J. *Trends and Silvicultural Significance of Upland Forest Successions in Southern New England*. Bulletin 22, Yale School of Forestry, 1928.

[2] Paton, R. R. *The Relative Importance of Origin of Mature Mixed Hardwood Stands*. Unpublished thesis, Yale School of Forestry, 1926.

HEMLOCK-HARDWOOD TYPE

In many hardwood stands a mixture of hemlock is found. When this occurs, the forest is classed as hemlock-hardwood type. Except for the addition of hemlock the composition is the same as in the hardwood type. Hemlock alone of the native conifers has the ability to establish its seedlings beneath the hardwoods and the persistence to live and grow until a dominant position in the stand is secured (Plate 8). Sometimes patches of pure hemlock occur (Plate 9). These are included in the hemlock-hardwood type as being too small for recognition as a separate type.

Just as the old field type is replaced naturally by the hardwood type, so the latter is converted to the hemlock-hardwood type. Fire protection is necessary, since hemlock does not sprout from the stump and the seedlings are easily killed. Instances can be found where hemlock established itself on old fields along with the hardwoods and accomplished conversion from old fields directly to the hemlock-hardwood type. The hemlock-hardwood type is an advance toward a more stable composition. Indeed, it is accepted as the permanent or climax forest type for this region. In other words, the type which can hold its place permanently against the invasion of new species (Plates 10 and 11).

PINE TYPE

The conversion of old fields to the hardwood type by natural seeding is often such a slow process that resort is taken to artificial regeneration. Common practice is to plant with pine those portions of the old fields which are free of brush and hardwood trees (Plate 12). In this way a pine type has been created.

At first white pine was the principal tree used (Plate 13). Scotch pine was planted in small quantities for a few years. Now red pine is planted in preference to Scotch pine (Plates 14 and 15). Since Scotch pine is an exotic species it is not likely to thrive so well as the native red pine. A practical disadvantage is the great difficulty experienced in obtaining seed from desirable strains of the species which will produce straight trees. In recent years red pine has been largely substituted for the white pine. A few acres of miscellaneous plantations—of European larch, Norway and white spruces, Douglas fir, and several others—have been classified under the pine type to avoid making other types.

Small areas have been stocked with various other conifers for purposes of experimentation. It is improbable that any other conifers can be found which will equal red and white pines as desirable species for commercial planting.

A small portion of the pine type was established on land already forested by hardwoods. Such plantations are either small experimental areas or else are strips bordering the reservoirs. In this latter location it is desirable to create a coniferous belt next to the water. The evergreen foliage of the pines does not blow into the water so readily as do the hardwood leaves. Foliage is objectionable in the water as it causes discoloration. The belt of pines, once it grows high enough to be effective, catches and holds the hardwood leaves and prevents their blowing into the water. Maintenance charges now incurred for removing leaves from the reservoirs can be reduced after the coniferous belt is developed.

HARDWOOD SWAMP TYPE

All swamp areas forested with hardwoods belong to this type. Red maple is the chief species, with elm, black ash, and swamp white oak as its most frequent associates (Plate 16). Pure stands of red maple are not uncommon. The thrift of the stands on swamp land depends largely on the amount of moisture contained in the soil. Some of the swamps are so wet as to restrict the tree growth to scattered, stunted individuals, while in other less moist situations conditions for growth approximate those occurring on uplands of medium quality.

CEDAR SWAMP TYPE

Southern white cedar occupies a few particularly wet swamps in the eastern portion of the Eli Whitney Forest. Red maple is the commonest associate of the southern white cedar. Most of the cedar is in an unhealthy condition and probably it will be replaced naturally by the red maple.

UTILIZATION OF FOREST PRODUCTS

The bulk of the material harvested from the Eli Whitney Forest goes to the market in the form of lumber, railroad ties, piling, and cordwood. New Haven and the other cities and towns surrounding the forest consume most of the material cut. Good railroad facilities and excellent highways make it possible, however, to reach markets outside the territory.

Lumber and piling are the most valuable products. Hence trees are cut into these two products whenever of a suitable size and quality. Profitable logs for the production of lumber from hardwood species are those 11 inches or larger in diameter at the top, reasonably straight, and free of large knots. Smaller logs down to an 8-inch top and logs of inferior quality are more valuable as ties. Hence the poorer classes of trees and the knotty upper logs of trees containing good quality lumber are cut into ties. Conifers (pine, hemlock, and cedar) can be used to smaller top diameters for lumber than the hardwoods. Piling requires trees reasonably straight for lengths of 25 feet and upward. It is taken from medium-sized trees that are suitable in size for lumber, chiefly from trees 10 to 16 inches in diameter breast high. When marketed as piling, such trees are usually more profitable than if cut into lumber.

Cordwood cut only from the hardwood species is used in large quantities by the brickyards, of which there are several in the region. Within recent years oil fuel has reduced the amount of cordwood taken by the brickyards. It appears unlikely, however, that cordwood will be entirely replaced by oil. Cordwood is still purchased by householders as fuel, though this use is shrinking, due to competition of coke and other fuels. The cordwood cut on the Eli Whitney Forest is obtained from the branches and tops of the trees used primarily for lumber, ties, and piling and from dead or diseased trees and inferior species that are removed in thinnings.

The different species of oak lead in commercial importance at present because of their abundance and high technical value. Two of the more profitable uses of the oak are as thick planking and piling. Other hardwood species go into railroad ties, lumber, and piling, depending on their quality and the current demands of the market. Hemlock is sawn chiefly into dimension stock and rough boards or cut for piling. Occasionally a little cedar is sawn into boards for cedar chests, but, because of its small size and its durability when in contact with the ground, the cedar is usually put into fence and vineyard posts.

The timber is sawn mainly by portable steam or gasoline-driven mills cutting less than 5,000 feet, board measure, per day, though a few stationary mills run by water power or steam are located in the region. The portable mills can be moved easily into the relatively small patches of forest in which the merchantable timber occurs. A gasoline-driven mill can be set up for as small a cut as 30,000 feet, board measure (Plates 17 and 18). While the work of cutting and hauling logs to the mills may proceed throughout the year, most of the logging is concentrated in the fall and winter months. After being sawn at the mills, the lumber may be stacked near-by for several months before being hauled out. Ties are sawn and peeled at the mills and then loaded on railroad cars. Piling is cut in the long lengths desired and delivered to the purchaser. Cordwood is cut into 4 or 5-foot lengths, piled, and left in the woods for about a year to season.

Owing to the unusually good road system which exists in the territory, the products of the forest often are hauled by truck directly to the purchaser. A veritable network of hard-surfaced state highways supplemented by good county and town roads cross and recross the region. Each division of the forest is contiguous to one or more good roads. Within the forest itself a comprehensive system of woods roads is being developed to coördinate with the outside road system. Eventually every part of the forest will be readily accessible. Steam and electric railroads are numerous in the territory, and no part of the property is more than nine miles from a railroad, while the average haul is under five miles. While other factors play an important part, the existence of this excellent transportation system has much to do with making the practice of forestry economically feasible on the Eli Whitney Forest.

In making sales of lumber, ties, or piling the custom has been to sell the material on the stump, the purchaser himself cutting the trees and hauling out the products. Cordwood has been sold in some cases on the stump, but usually this product is chopped by the Water Company and the resulting cordwood sold by the pile in the woods. On the Maltby and West River divisions, where small engines and cut-off saws are installed, some of the cordwood is sawn into short lengths and retailed in New Haven (Plate 19).

Undoubtedly the most important problem requiring attention on the Eli Whitney Forest is the question of a more satisfactory utilization of forest products. The ability to sell cordwood in large quantities at present is the key to the intensive practice of forestry in this region. Far superior results can be secured in the quality and quantity of timber produced when the small and inferior trees can be cut for cordwood and their competition with the more promising individuals eliminated. As long as this class of material can be sold at a profit or for enough to cover expenses, many operations which are of high ultimate value to the forest can be carried on. The market for cordwood, however, is becoming more selective and is decreasing in total volume consumed. This means that, in order to keep the business, more attention must be paid to the quality of cordwood produced (particularly concerning the details of its manufacture) and to the selling of the product.

Timber, while selling more readily than cordwood, does not bring the prices which its closeness to centers of consumption seems to warrant. The situation is not only local but is common throughout southern New England. The presence in local markets of plentiful supplies of finely manufactured, carefully graded, high quality hardwood and coniferous timber shipped in from the South and West has supplanted the local timber, which is lacking in one or more of these attributes. Many wood-using industries have moved away from this territory to be nearer the source of their raw material. Since the local consumption of timber is large and the native species possess excellent technical qualities, the demand for local timber can certainly be improved. Increased cost and more limited available supply of timber imported from the South and West, better grading, manufacture, and marketing of the local timber will hasten the movement. The practice of forestry resulting in an increased growth and enlarged annual cut and guaranteeing a permanent supply of timber promises to be a vital factor in reëstablishing local timber as an important element in the market.

The situation on the Eli Whitney Forest can be helped ultimately by the Water Company itself handling the logging and manufacture of the timber. The principal reason why this has not been done heretofore is that the volume of timber which should be cut annually from the forest is at present too small to warrant the undertaking. To prove successful there must be a competent man in charge whose employment at first would not be justified by the volume of business. The natural tendency would be to cut too much from the forest in order to make the manufacturing end of the business show a better temporary profit, disregarding the fact that a heavy cut is incompatible with the purposes of management.

For these reasons the present policy of selling the timber on the stump is considered sound and should be continued until the annual cut can be materially increased. A modification of this plan which merits trial consists in the owner cutting the logs and selling them delivered to the purchaser at his portable mill or other designated point.

SUBDIVISION OF THE FOREST

For purposes of systematizing and controlling the management on the Eli Whitney Forest, the total area has been divided and subdivided into units of convenient size for handling. The establishment of these subdivisions has proven to be of material assistance in many of the activities of management. The forest inventories, when obtained by subdivisions, show not only the amount of timber present but also the definite location of each merchantable stand and its volume. Cutting operations are allotted to definite areas and can thus be controlled. Keeping a record of operations in the forest has been simplified, and the value of these records has increased because they apply to definite small areas. Protection of the forest and other administrative details have been facilitated by the existence of the subdivisions.

The location map opposite page 14 shows that the forest is separated into ten major watersheds. Since water supply is the major interest of the owners, it is logical that the primary separation of the forest into smaller units should be on the basis of watersheds tributary to specified reservoirs. Each of these watersheds are termed divisions. The boundaries of these watersheds are commonly governed by topography, though in the case of the Maltby, North Branford, and Saltonstall divisions tunnels and canals have resulted in throwing together several watersheds as tributaries to one reservoir. The ten divisions range in area from 245 to 10,500 acres. It has been found that even the smallest of these divisions must be further subdivided in order to secure effective control.

In establishing a further subdivision upon the ten major divisions it was desired to set up areas, termed compartments, each of which would contain only one land class and one age class. Under local conditions it is believed that the ideal management unit or compartment is an area of approximately 40 acres in size. If it were possible to establish compartments of this size containing the desired uniform land class and age class, many features of management, such as the keeping of records and the allocation of operations, would be simplified. Such uniformity is rarely attainable, since on most 40-acre tracts in this region a variety of types as well as ages of timber commonly occur. Consequently, within nearly every compartment, a further subdivision is required to separate each land class and age class. This is the smallest and final unit recognized and is termed the stand. Most of the compartments will be found to contain two or more stands. It is anticipated that these stands are only temporary and may be altered and combined with adjoining stands. The compartment on the other hand, once established, remains unchanged in area and location.

In forming the compartments, so far as possible, natural features, such as lakes, large streams, and ridge lines, or pronounced artificial lines, such as roads, power lines, and large ditches, are taken as the boundaries. This facilitates the work of subdivision and at the same time gives permanent boundary lines. In some cases, however, it is necessary to establish artificial lines through the woods to prevent obtaining too large or poorly shaped compartments.

The maps of the Maltby and Saltonstall divisions, included opposite pages 28 and 30, illustrate this system of subdivision. In the two divisions there are 78 compartments averaging 35 acres apiece. The average number of subdivisions or stands inside each compartment is four.

FOREST RECORDS

The keeping of records for a forest property is an administrative activity which can easily be overemphasized and yet one where failure to spend enough effort may be regretted in the future. In working out the forms now in use on the Eli Whitney Forest several important features of record keeping were borne in mind. For example, to be of value records must not be too detailed and complicated; they must contain all information obtainable that will be of use now or in the future, and nothing more; and this use must be important enough to justify the cost of their compilation.

On this basis it was believed that a graphic record in the form of two maps for each tract was necessary. One of these shows property boundaries, interior alienated holdings, land classes, age classes, compartment subdivisions, streams, lakes, roads, and some other details. Samples of this kind of map are inserted in the text, opposite pages 28 and 30. The other, an operation or progress map, shows the location and extent of past and current operations.

In addition to these maps a permanent card record is kept for each compartment. This card carries the data on volume, growth, area, and other details which are necessary for the intelligent planning of operations. Maps and compartment cards supplement one another and furnish an adequate set of records not too detailed to be economically practical.

The two sides of a sample filing card for Compartment 4, Maltby division, are shown on pages 27 and 28. The original card is 8½ by 11 inches in size.

ADMINISTRATION AND PERSONNEL

Each division, when developed as a water supply unit, is placed under a foreman who has a permanent crew of men adequate for properly caring for the reservoirs and watershed. Most of the year these men are busy on work chargeable to water supply. Incidentally they assist in fire protection and various forestry operations, such as the planting of pines in the spring season. During the winter months work around the reservoirs slackens and it is convenient to furnish employment in the forest. At such times release cuttings and pruning can be carried on. One of the reasons for carrying on such work is to furnish some of the permanent employees with winter work.

The foremen and some of the men as a result of several years of experience have become trained in the technique of various forestry operations. It is a decided advantage to have men with this experience permanently in the organization.

Most of the cordwood is cut by specially employed woodchoppers who are paid by the cord. Their wood is measured and inspected by the divisional foremen. Forest products of better grades than cordwood usually are sold standing in the forest to lumbermen whose work is inspected by the foremen.

Within recent years most of the trees cut have been individually marked. The selection and marking of these trees is done by the forester. Experimental sales have been tried when no marking of individual trees was done, the cutting being controlled by general specifications. The results were uniformly unfavorable, and now marking of individual trees for cutting is the standard practice.

The forester in most matters acts in an advisory capacity, recommending both the general policy and many details of the work. Actual operations in the field are directly in charge of the company's various executives.

FOREST PROTECTION

As in agriculture, so in forestry, efficient protection against the numerous enemies which threaten the crop must be secured or failure of the enterprise results. Since the practice of forestry began on the Eli Whitney Forest the best commercial species (chestnut) has been exterminated by a plant disease, the chestnut blight. This was a foreign disease of epidemic character against which there was no defense once the disease became established. The destruction of the chestnut was unprecedented and is not likely to be followed by a similar happening.

While there are numerous insects, fungi, and small animals which are injuring the forest trees, none are such virulent enemies as to threaten general destruction. Direct action cannot be undertaken against most of these pests because the expense involved would be out of proportion to the damage done. Some pests are combated in an inexpensive way by removing the

Date Nov 30 1929

Division Maltby

Compartment 4

ELI WHITNEY FOREST

Description Chlorite schist ridges with general slope toward lake and small stream in center. Easy logging chance with outlets to south & east

Stand	Area Acres	Soil	Species	Dom. Height Feet	Site Index Feet	Basal Area Sq. Ft.	VOLUME			GROWTH		
							Cu. Ft.[1]	Feet B.M.	Cords[2]	Cu. Ft.[1]	Feet B.M.	Cords[2]
Hardwoods 21-40	22.0	Southern portion-poor and	Oak	34		832	12550	12000	143		2300	
		shallow, sandy clay, a	Other hardwoods			398	6280	2400	65		500	
		chlorite schist ridge.	Cedar			1	20					
		Northern portion-medium,										
		loam, deeper, more level.										
Hardwoods 41-60	13.9	Medium to good, clay loam	Oak	52		716	14370	46100	82		4700	
		good depth in western	Other hardwoods			225	4010	3300	43		700	
		half. Remainder on										
		rocky ridge-medium,										
		shallow.										
Hardwoods 81-100	1.9	Medium to poor, sandy clay,	Oak	83		102	2610	15000	4		500	
		shallow except for level	Other hardwoods			18	400	1800	1		100	
		pockets. West slope of										
		ridge.										
Hdw. Swp. 21-40	2.1	Deep, clay, wet year	Oak	35		38	600	200	6			
		around.	Other hardwoods			79	1200	1100	14		200	
Totals	39.9					2409	42040	81900	358		9000	

[1] Total Cubic Feet Inside Bark

[2] Exclusive of Merchantable Logs

COMPARTMENT CARD—FACE

Stand	Condition	Recommendations[1]	RECORD OF OPERATIONS				
			Date	Character	Amt. Cut	Cost	Returns
Hardwoods 21-40	Fully stocked, some evidence of fire, especially in southern portion of stand. Some strumella canker in northern portion.	Thinning near end of period.					
Hardwoods 41-60	Density .7 A little evidence of previous fires and strumella canker.		1926	First thinning on 3 acres	31.5 cords	\$2.50 per cord to chop.	Valued at \$5.00 per cord in the pile.
			1929	First thinning on 10.9 acres	68 cords	\$3.00 per cord to chop.	
Hardwoods 81-100	Scattered large trees. Density .1 to .2 Heavy understory coming in. Some bad fire scars on older trees. Area recently purchased.	Remove upper story					
Hdw. Swp. 21-40	Fully stocked. No evidence of fire. A few merchantable stems of older age in the northwest corner.						

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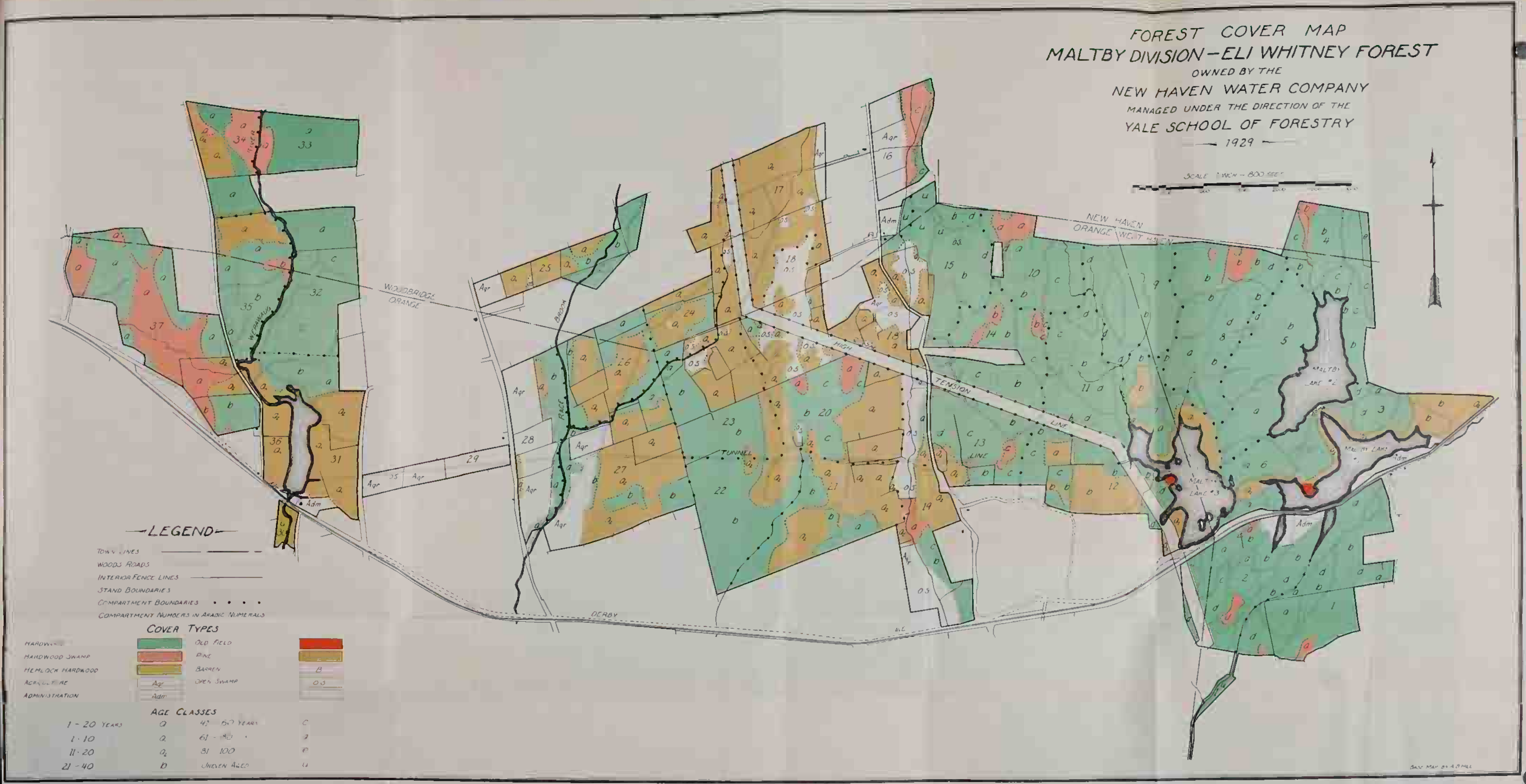
[1] Next ten-year Period

COMPARTMENT CARD—REVERSE


FOREST COVER MAP
MALTBY DIVISION – ELI WHITNEY FOREST
OWNED BY THE
NEW HAVEN WATER COMPANY
MANAGED UNDER THE DIRECTION OF THE
YALE SCHOOL OF FORESTRY
1929
SCALE 1 INCH – 800 FEET
NEW HAVEN
ORANGE
WEST HAVEN
WOODBRIDGE
ORANGE
WEPAWAUG RIVER
RACE BROOK
HIGH TENSION LINE
TUNNEL LINE
DERBY AVE.
MALTBY LAKE #1
MALTBY LAKE #2
MALTBY LAKE #3
Adm
Agr
OS
1
2
3
4
5
6
7
8
9
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34
35
36
37
LEGEND
TOWN LINES
WOODS ROADS
INTERIOR FENCE LINES
STAND BOUNDARIES
COMPARTMENT BOUNDARIES • • • •
COMPARTMENT NUMBERS IN ARABIC NUMERALS
COVER TYPES
HARDWOOD 🟩
HARDWOOD SWAMP 🟥
HEMLOCK HARDWOOD 🟨
AGRICULTURE Agr
ADMINISTRATION Adm
OLD FIELD 🟥
PINE 🟧
BARREN B
OPEN SWAMP OS
AGE CLASSES
1 - 20 YEARS a
1 - 10 a_1
11 - 20 a_2
21 - 40 b
41 - 60 YEARS c
61 - 80 d
81 - 100 e
UNEVEN AGED u

injured trees in cutting operations. The strumella canker, which is the worst disease attacking the oaks, is fought in this way (Plate 20). In nearly all cuttings in oak stands some trees affected with the disease are found and taken out. Conditions in the forest as regards all plant pests are continually under observation, and cutting operations are located where most needed. Occasionally a pest like the white pine weevil requires special treatment. Fortunately in this region there is practically no danger of loss from the white pine blister rust, since wild varieties of ribes (which spread the disease) are practically nonexistent, while the cultivated black currant is scarce.

Forest fires occur each year in the region, and usually some burn on the Eli Whitney Forest. This region, however, is now one of low fire risk. Previous to 1907 the fires were much more prevalent. Indeed, a good many tracts were purposely burned over each year. Records kept since 1907 show that there have been 81 fires on the property. The principal fire causes are smokers (responsible for 60 per cent of the fires), brush burning (19 per cent), and railroads (7 per cent).

The largest fire burned over 125 acres, while the average size is 5 acres. It is believed that the cumulative educational effect of the state forest fire organization and of the New Haven Water Company's fire prevention and control activities is now being experienced. During each of the last five years, 1925 to 1929 inclusive, an average of 18 acres or approximately 0.12 of one per cent of the total area of the Eli Whitney Forest burned over.

The company's organization for protection of the water supply functions also to guard against forest fires. There are two fire seasons each year: one in the spring of about six weeks duration during March, April, and early May; and the other of shorter duration in the fall after the leaves have dropped. During these periods the men around the reservoirs keep close watch for fires. On dangerous days, particularly Sundays and holidays, they may patrol especially for fires. In some cases guards traveling in cars have been used for the fire season. A uniformed motor patrolman is employed the year round to protect the water supply. Undoubtedly the fact is generally known that these lands are watched, and it has had a deterrent effect on the class of people who formerly roamed the woods and set many fires.

Woods roads are kept brushed out so as to afford easy access to all parts of the forest in time of fire and, if necessary, to serve as lines from which the fire may be attacked (Plate 21). The roadbeds of the forest roads are gradually being improved so as to permit passage of trucks and light cars. Such improvements are of value not only in strengthening protection against fire but, what is more important still, in making the forest more accessible for the removal of forest products. The foundation is now being laid for a comprehensive road system, the development of which must be gradual and must come as a result of increased cutting of forest products and increased income.

Around some of the pine plantations special fire lines have been developed. The best type is a plowed fire line 6 to 10 feet in width which is kept free of inflammable litter by harrowing (Plate 22). Such lines appear justified alongside of certain highways. On the whole, special fire lines are relatively expensive, since an equal degree of protection can usually be obtained in other ways at less cost.

Where railroads using coal as fuel pass through the forest, special fire lines are used. These consist of a cleared strip 50 to 100 feet in width which is burned over as often as needed (Plate 23). On the outer edge next the forest and on the inner edge beside the right of way narrow plowed strips are maintained free of litter. Fires originating on the right of way do not cross these fire lines, and it is difficult for a fire to start on the fire line itself and spread to the adjoining timber.

Portions of the Eli Whitney Forest are under observation from lookout towers maintained by the state forester for detecting forest fires. Most of the fires which start are either discovered by the company's employees or reported over the telephone by people living in the region. The foreman on each division has tools for fire fighting. He goes immediately with his crew to each fire discovered on his division. Additional tools and equipment are kept in the company's supply yard in New Haven ready to be dispatched by truck to a fire. Close coöperation is maintained between the company's employees and the town forest fire wardens employed by the state.

MANAGEMENT POLICY

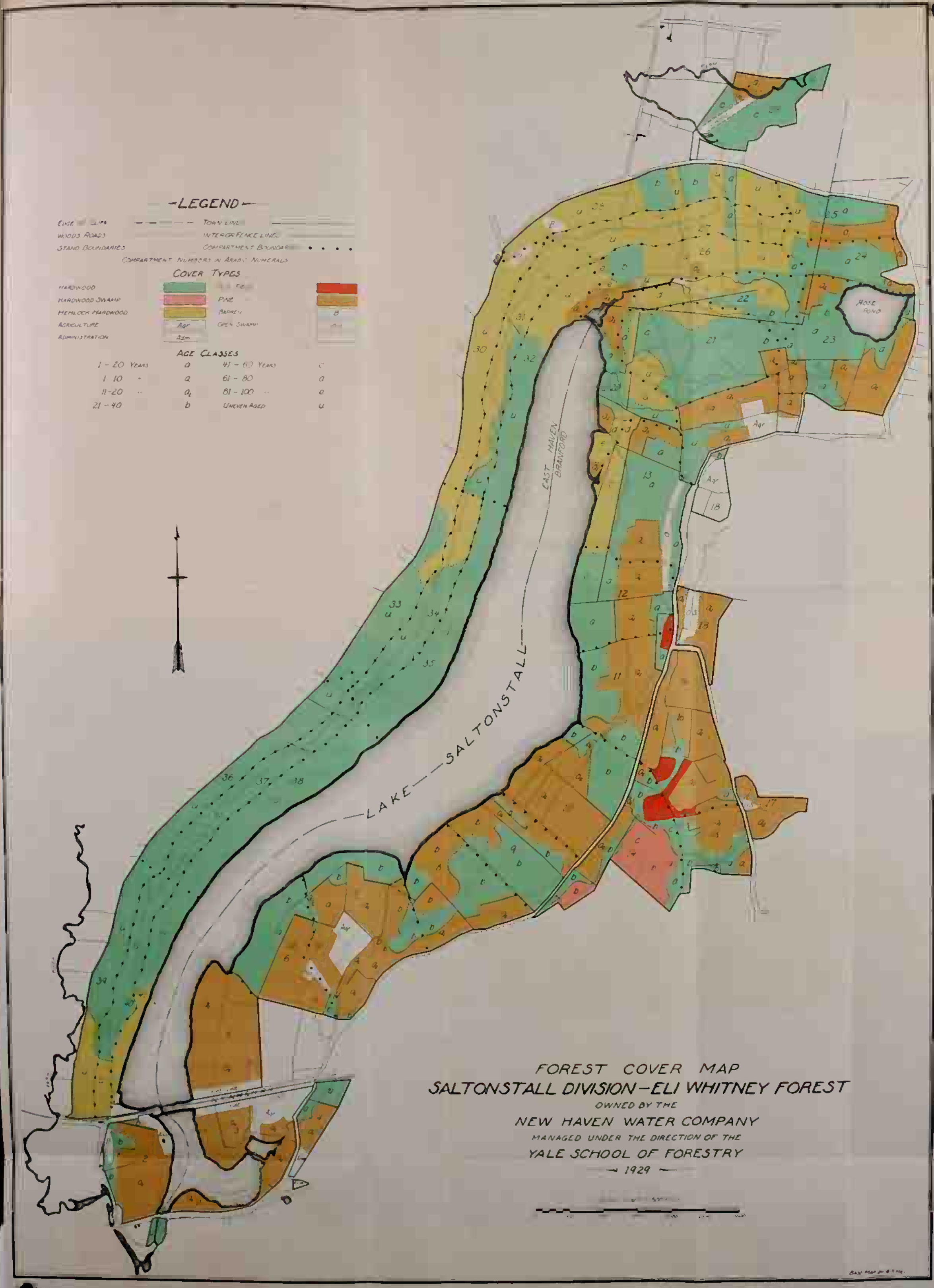
The New Haven Water Company, first in acquiring land and later in building up the Eli Whitney Forest to its present size, was actuated by the desire to secure the highest type of natural protection for the watersheds and reservoirs. A well-stocked forest is unexcelled in furnishing this protection (Plate 24). Consequently, the company's policy has been to establish such a forest on open areas and to maintain and improve in quality the existing forest.

If an excellent protection forest can be established and maintained in a manner to pay its way and return a profit, this should be accomplished. As a matter of fact, the commercial development and operation of a forest is not inconsistent with its functioning as a protection forest. In this particular region the two purposes, protection and commercial profit, can safely be combined. Hence, the policy adopted by the New Haven Water Company, while developing an excellent protection forest, aims to conduct the work so that wood and timber may be sold and the operations made profitable. As a further objective the creation and maintenance of pleasing landscapes is attempted. This purpose also does not need to be in conflict with commercial use.

The popular idea sometimes encountered, that all cutting of trees in the forest must be prevented if good protection and pleasing landscape effects are to be secured, is erroneous. Cutting of trees is the most effective tool which the forest manager has at his command, not only for securing a steady supply of timber, but also for developing and maintaining satisfactory forest landscapes and the best protection forest.

From all three viewpoints it is essential for satisfactory results that the maximum cut (for any given period such as one year) of wood and timber be held within certain limits. Very rarely can more material be removed than is equivalent to the growth of the forest during that period. If a larger cut is made, the effectiveness of the forest in accomplishing its functions is diminished. In cases such as that in the Eli Whitney Forest, where some areas are still bare of forest and where too large a proportion of the forest is in the younger age classes, much less than the growth is cut.

The growth is allowed to accumulate and build up the growing stock of trees. This is a


-LEGEND-
EDGE OF SLOPE
TOWN LINE
WOODS ROADS
INTERIOR FENCE LINES
STAND BOUNDARIES
COMPARTMENT BOUNDARIES
COMPARTMENT NUMBERS IN ARABIC NUMERALS
COVER TYPES
HARDWOOD 🟩
OLD FIELD 🟥
HARDWOOD SWAMP
PINE
HEMLOCK HARDWOOD
BARREN B
AGRICULTURE Agr
OPEN SWAMP
ADMINISTRATION Adm
AGE CLASSES
1 - 20 YEARS a
1 - 10 " a
11 - 20 " a₂
21 - 40 b
41 - 60 YEARS c
61 - 80 d
81 - 100 " e
UNEVEN AGED u
LAKE SALTONSTALL
EAST HAVEN
BRANFORD
ROSE POND
Agr
Base Map by N.H.W.Co.

FOREST COVER MAP
SALTONSTALL DIVISION—ELI WHITNEY FOREST
OWNED BY THE
NEW HAVEN WATER COMPANY
MANAGED UNDER THE DIRECTION OF THE
YALE SCHOOL OF FORESTRY
— 1929 —

necessary step before the forest can reach its highest usefulness as a protective cover, as a productive commercial forest, or from the æsthetic standpoint. More large timber is needed for good protection and the best landscape effects. High production of better quality material can be secured only when the forest contains large bodies of middle-aged and older timber.

The policy for the last two decades has been to cut the overmature timber, dead chestnut, inferior species, defective individuals, and in thick stands those trees whose removal would stimulate growth on the remaining more valuable trees and thereby increase the production on that area. In pursuance of this policy 7,300,000 feet, board measure, of lumber, piling, poles, and ties and 30,000 cords of fuelwood have been removed from the forest. This is an average annual cut for the last 23 years of 320,000 feet, board measure, and 1,300 cords.

The average annual cut for the last 23 years is much lower than the present annual growth on the Eli Whitney Forest (Table VI). This is as it should be until an adequate growing stock of timber has been accumulated and until more accurate knowledge of growth has been obtained.

The present volume or growing stock of timber is shown in Table V. This is expressed in feet, board measure, which is the principal unit used locally. The smallest trees measured for lumber were 8 inches in diameter at breast high for all broad-leaved species and 5 inches in diameter at breast high for the conifers; namely, pine, hemlock, and cedar. Knowledge as to the amount and character of the merchantable products present in a forest is of primary importance in determining both the policy and the details of management. The cut of forest products which can be made year after year in the forest depends to large extent upon the present volume. The distribution of the merchantable timber throughout the various stands indicates the places where cuttings can be made and enables an approximate determination in the office as to the amount which can be secured from a given stand.

TABLE V. AMOUNT OF STANDING TIMBER IN THE ELI WHITNEY FOREST

Age in years	*Oak*	*Other hardwoods*	*Hemlock*	*Pine*	*Cedar*	*Total**
		Thousand feet, board measure				
1-20	250	266	79	1,536	22	2,153
21-40	2,730	2,534	205	213	226	5,908
41-60	3,093	2,348	412	69	66	5,988
61-80	1,467	999	178		12	2,656
81-100	207	454	461		49	1,171
Unevenaged	3,731	2,038	1,876	193	133	7,971
Total	11,478	8,639	3,211	2,011	508	25,847

* Does not include timber on approximately 1,800 acres not yet mapped.

Knowledge as to the increase in volume made annually or periodically by the forest is essential for the practicing forester, but exact information on this subject is difficult to secure without careful observation over a long period. Indeed, the amount produced by a forest is constantly changing in response to changes in soil conditions, injuries from fire, method of treatment, and other factors. In well-managed forests the rate of growth should tend to increase. The simplest way of estimating the growth of a forest is by the use of average figures of growth per acre per year applied to the area forested or separately to the areas of the types. The estimate of growth in Table VI has been made on this basis for the chief commercial product, lumber. These figures are considered to be conservative, particularly for the hardwood and hemlock-hardwood types.

TABLE VI. ESTIMATED ANNUAL GROWTH IN LUMBER IN THE ELI WHITNEY FOREST

Type	*Area in acres*	*Annual growth in lumber** *Per acre*	 *Totals*
		Feet, board measure	
Old field	988		
Hardwood	12,676	175	2,220,000
Hemlock-hardwood	333	300	100,000
Pine	2,242	600	1,340,000
Hardwood swamp	609	100	60,000
Cedar swamp	59		
Totals	16,907	220	3,720,000

* Does not include growth on approximately 1,800 acres not yet mapped.

No set method of fixing the maximum cut to be removed during the next few years is followed. The amount of merchantable material standing in the forest, the distribution of the timber by age classes, the condition and location of the older timber, and the character of the treatment needed in the individual stands are all considered, always keeping in mind the objectives of management. An arbitrary decision is eventually made.

At the present time the cut for the next five years in the hardwood, hemlock-hardwood, and hardwood swamp types is restricted to a maximum total of 1,700,000 feet, board measure, which may be taken out in annual or periodic installments. This allowed cut is purposely set far below the growth of these types in order to allow the growing stock in the forest to accumulate. For best results in the way of timber production, scenery, and protection, there should be a growing stock of approximately 80,000,000 feet, board measure, standing in the forest. Until somewhere near this volume is obtained the annual cut must be kept well below the growth.

No lumber cut, other than a small amount secured in thinning a few of the older plantations, will be made in the pine type for the next ten years, as the pine stands are all less than thirty years of age.

Since cordwood is cut from the tops of those trees harvested for lumber, from short-lived species like gray birch, from dying trees, or in partial cuttings which leave the stand in condition for better growth, no restriction need be placed on the amount of cordwood cut. It will be difficult to find a market for more than 2,000 cords of fuelwood per year, hence for all practicable purposes the cut is restricted to not more than this amount.

After the total annual cut is decided upon, its allocation to individual stands in the forest is based on the condition of these stands. Enough timber or cordwood must be cut in one stand or group of stands closely adjoining to make an operation sufficiently large to be handled economically. Ordinarily this proviso is not difficult to satisfy.

TREATMENT BY LAND CLASSES

Methods of treatment, results, and accomplishments in furthering the policies outlined will be taken up separately for each land class. In systematizing the management of forest properties these land classes are indispensable. This is particularly the case with the forested land classes, or forest types, as they are commonly designated. Each forest type includes many stands, usually not contiguous, representing a wide range in age from stands of reproduction up to those composed of mature timber. One method of treatment (two in the case of the hardwood type) applies to all these individual stands forming the type. Each stand requires detailed treatment suited to its position in the range of ages. For example, a very young stand may need a release cutting, a middle-aged stand requires a thinning, while in an old stand harvesting of the timber may be called for. All these operations are provided for under the method of treating this particular forest type.

Methods and details of treatment have been developed on the Eli Whitney Forest as a result both of practical experience and of scientific experimentation. The extent and variety of the operations in the last three decades has furnished opportunity for acquiring experience. The School of Forestry has been carrying on research in the Eli Whitney Forest for more than twenty years. At present 66 permanent sample plots are maintained upon which a variety of experiments covering long periods of time are in progress. Investigations of shorter duration are carried on each year.

The methods of treatment set forth in the following pages are those which up to date have proved best on the Eli Whitney Forest. Present practice is not looked upon as a fixed thing. Much remains to be learned, and undoubtedly further experience and research, as well as new economic conditions, such as a change in the form of wood use, may suggest departure from the treatment now approved.

OLD FIELD TYPE

The natural process of reversion to forest is accelerated and the character of the new forest controlled by restocking artificially those portions of the old field type not as yet occupied by trees. Only the open portions of a field are planted. Patches of brush and clumps of cedar and birch are left untouched to gradually revert to the hardwood type. It is considered too expensive to attempt artificial conversion of the brushy areas stocked with shrubs. Planting is going forward at the rate of approximately 100 acres a year and, unless other old fields are acquired or the planting is diverted to agricultural lands, can be finished in the next ten years.

Red pine and white pine are the trees commonly planted. Three-year-old transplant stock has proved to be best suited to the conditions encountered on the old fields which usually are characterized by heavy grass sod. The sod competes strongly with the planted trees. Any tree smaller than a three-year-old transplant has difficulty in becoming established in the thick grass. Since 1910 the planting stock has been grown from seed in a small nursery on the Maltby division.

HARDWOOD TYPE

In the hardwood type are found many valuable timber trees. The oaks stand in first place because of their abundance as well as for the value of their wood. Black, red, white, and chestnut oaks are all favored. Of these, the black and red oaks grow fastest and the white oak has the most valuable wood, while the chestnut oak surpasses them all in its ability to thrive on dry rocky sites. Basswood, not an abundant tree, grows exceedingly well when it occurs. Black birch and hard maple, while less valuable, are aggressive in seeding up openings. The latter is especially helpful as an understory beneath the oaks. On the best soils with excellent moisture conditions yellow poplar, white ash, and red maple are added to the list of desirable species.

These hardwoods are grown for timber and harvested when 80 to 90 years of age. A period of this length is required to produce on average soil yields of timber satisfactory in amount and quality for present-day uses. On good soils and with the faster growing species the time is shortened as much as twenty years, and on the poorer soils it is increased correspondingly. Stands repeatedly thinned from early middle age reach commercial maturity in a shorter time.

The tops of felled hardwood trees, whether these trees are utilized for timber only or for timber and cordwood combined, are left on the ground after the removal of the merchantable portion of the tree. When cordwood is cut, the tops and limbs remaining are less than 3 inches in diameter. When only timber is cut, tops with butt diameters of 6 to 8 inches are left. These hardwood tops (even the largest) are too open and spreading to seriously hinder the development of the new crop of seedlings (Plate 25). Their presence increases the difficulty of stopping a forest fire and may increase the severity of a fire. However, the risk of a fire starting depends on the condition of the fallen leaves on the ground rather than upon the tops of felled trees. Hardwood tops quickly absorb moisture and are not inflammable on the average upland site after two years. The policy has been to spend no money in disposing of hardwood tops but to seek protection against forest fires through cheaper and more efficient means.

The hardwood type occurs both in evenaged stands (the result of earlier clear cutting) and in unevenaged stands, where trees of different ages are mixed together singly or in groups. The unevenaged stands were developed by past cuttings which removed only the larger sized trees. These are the two principal forms in which a forest grows. Treatment for the evenaged form will differ from that given the unevenaged stands; hence each should be discussed separately.

Treatment for evenaged stands. Evenaged stands are allowed to grow untouched until most of the trees are large enough for cordwood. On average sites this will happen soon after the thirtieth year.

A thinning (technically termed a low thinning) is made at this time, removing sound dead material and the smaller and least desirable trees in such a way as to leave the area fully stocked with the best thrifty trees. In a few years the crowns of these trees spread out and occupy the area completely. Five to ten cords per acre, approximately one third of the volume, is removed in this thinning. In eight to fifteen years, depending upon the rapidity with which the trees grow, another thinning is needed. The thinnings are repeated at appropriate intervals until the time arrives for harvesting the stand (Plates 26, 27, 28, 29, and 30).

The thinnings not only bring in a small immediate profit but increase the final returns by concentrating growth upon the best and larger trees and stimulating the growth of these trees. When oaks form a large percentage of the stand, as frequently happens, thinnings are particularly desirable, since trees of this genus need abundant room for crown expansion and rapid growth in order to produce timber of the best technical quality. Thinnings have been made for the first time on more than 900 acres and have been repeated on approximately 200 acres.

One effect of the thinnings is to encourage the development of numerous seedlings under the old stand. These seedlings provide an adequate new crop after the removal of the old stand. However, a crop of seedlings under the old stand is not restricted to thinned stands. Even in stands which have never been thinned adequate seedling reproduction usually is established under the old stand by the time the latter reaches sixty years of age.[3]

Eventually the stand reaches the size and age at which it will be harvested. Because of the presence on the ground of the new crop of seedlings, the mature stand, whether or not it has been thinned in the past, may be removed in one cutting at the time of its commercial maturity. It is replaced by the crop of seedlings supplemented by a few sprouts (Plates 31 and 32). When timber as old as eighty years is harvested, most of the stumps do not produce sprouts.

In the unusual cases where a new crop of seedlings does not occur beneath the mature stand, the latter is harvested in two cuttings instead of one. The first cutting removes 50 to 60 per cent of the volume. It is in effect a late and heavy thinning. The reduction of root competition and opening up the stand to the action of sun and wind normally result in the establishment of many tree seedlings. Within ten years after the first cutting enough seedlings usually are established so that the remainder of the mature stand can be removed (Plates 33, 34, and 35). This is termed the shelterwood method of reproduction, because the new crop is started beneath the shelter of the old trees.

Whether the old stand is removed in one or in two cuttings, the new crop which replaces it is essentially evenaged (Plates 36 and 37).

Along with the seedlings which arise in evenaged hardwood stands there develops, frequently to an undesirable extent, a cover of shrubs among which viburnum predominates. In some cases mountain laurel increases. The first impression gained upon observing the shrubby undergrowth is that it will prevent the establishment of tree seedlings. Undoubtedly their numbers are reduced and their development for a time hindered. Usually the shrubs occur in patchy distribution. The tree seedlings become established between the patches of shrubby undergrowth and in small numbers within the clumps themselves. The greater height growth[4] made by the tree species enables them soon to outstrip the shrubs and eventually dominate the clumps (Plates 38 and 39).

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[3] Mowat, E. L. *A Study of Advance Reproduction in the Evenaged, Unthinned Connecticut Hardwood Stand.* Unpublished thesis, Yale School of Forestry, 1927.

Depredations by insects, small rodents (chiefly squirrels and mice), and by rabbits reduce the amount of oak reproduction.[5] In some places this proves serious, but on the whole enough oak seedlings become established to maintain the predominance of oak in the forest. Reproduction of chestnut and white oaks, whose seeds germinate in the fall, is more abundant than of the red and black oaks, whose seeds are exposed during the winter and do not germinate until spring. Seed weevils and the small rodents destroy a large proportion of the entire acorn crop. Rabbits cut off the terminal shoots and branches of small oaks and other hardwoods for food. The deformation repeated for a series of years may finally kill the tree or so reduce its height growth that other trees or shrubs overtop it.

The hardwood type on the Maltby division is composed of evenaged stands treated according to the method just described. Stands in the 1 to 20, 21 to 40, 41 to 60, and 61 to 80-year age classes can be observed. Many of the stands have been thinned one or more times. New crops established as a result of harvesting the mature timber are in evidence.

Treatment for unevenaged stands. Where the stands are at present unevenaged, or where it is desired to create a forest of such form, methods of cutting are employed differing radically from those described for evenaged stands (Plate 40).

In the unevenaged stand the selection method is practiced (Plates 41 and 42). When a stand is ready for cutting, 25 to 50 per cent of the volume of the stand in feet, board measure, is removed. The volume taken out is selected from among the oldest, largest, least thrifty, and less valuable trees. The purpose is to leave the merchantable trees which will make the best growth and to remove those which are the least promising. The trees which are left need not—in fact, should not—be distributed evenly over the area. Openings, ranging in area up to a half acre, are purposely created by the removal of all merchantable trees. Seedlings soon start in these openings. They have room to develop on the little clearing and create a new age class (Plate 43).

This style of cutting will be repeated every fifteen years in the same stand. After several of these selection cuttings the trees of the various age classes will be distributed by small groups. The profile of the forest is pleasingly broken, and better landscape effects are developed than in the evenaged form of forest.

One advantage of the selection method is that it lends itself readily to either crude or intensive operations. For example, if fuelwood is not readily saleable (as happens in some relatively inaccessible stands), only trees merchantable for timber are cut (Plate 44). Such cases are rare on the Eli Whitney Forest. On the other hand, where fuelwood is saleable, the cutting for timber is supplemented by taking out defective individuals and inferior species and by thinning dense middle-aged clumps.

[4] Leffelman, L. J., and Hawley, R. C. *The Treatment of Advance Growth Arising as a Result of Thinnings and Shelterwood Cuttings.* Bulletin 15, Yale School of Forestry, 1925, p. 39.

[5] Averell, J. L. *Reproduction Following Cuttings in the Hardwood Forests of Southern Connecticut.* Unpublished thesis, Yale School of Forestry, 1926.

An unevenaged forest is considered a better protection forest than the evenaged form. Superiority in landscape effects may be conceded. As producers of timber there should be little difference between the two forms. Therefore, on the whole, the unevenaged form is likely to prove the more satisfactory for the owners of the Eli Whitney Forest.

The hardwood and hemlock-hardwood types on the Saltonstall division are being managed as an unevenaged forest. The results of selection cuttings dating back over the last ten years can be studied on this division.

HEMLOCK-HARDWOOD TYPE

The successional relation between the hardwood and hemlock-hardwood types has already been described. Within recent years, as a result of fire protection, hemlock has been spreading rapidly through the hardwood type wherever the presence of seed trees made its extension possible[6] (Plates 45, 46, and 47).

On the Saltonstall division there were plenty of scattered hemlock seed trees and patches of hemlock timber twenty-five years ago (which is approximately the time when fire protection started). Consequently, conversion has gone forward rapidly. The Maltby division furnishes a sharp contrast. There were practically no hemlock seed trees on the area twenty-five years ago. Although carefully protected from fire, the hardwood type has retained its identity without conversion to the hemlock-hardwood type.

The object of management in the hemlock-hardwood type is to maintain a mixed forest of hemlock and the better hardwoods (Plates 48, 49, and 50). This combination is excellent from the protective, æsthetic, and commercial viewpoints.

Details of treatment are essentially the same as given for the hardwood type.

Evenaged and unevenaged forms of the hemlock-hardwood type are found. Probably a bigger percentage than in the hardwood type is unevenaged or at least susceptible to quick transformation to such form. The seeding in of hemlock over a considerable period of time is responsible for the irregularity in age which occurs. Hemlock appears in the mixture both as a part of the dominant cover and also as an understory beneath the hardwoods (Plate 51). This latter case occurs particularly on the areas recently converted from the hardwood type.

The hemlock with its dense foliage reduces the amount of the shrub undergrowth so abundant in the hardwood type. The hemlock in the same way hinders the start of the new crop of seedlings. When ready to reproduce a stand and harvest the old timber, the hemlock is opened up sufficiently to allow light and air to reach the ground in abundance and thereby encourage the establishment of seedlings.

Hemlock tops are more of a hindrance to reproduction than hardwood tops. If present in large quantity, the branches when cut from the main stem often form compact piles or windrows and may prevent reproduction altogether. For this reason such tops, which in the past have been left untouched, will either be placed in spots where reproduction is not wanted or else be piled and burned.

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[6] Merrill, P. H., and Hawley, R. C. *Hemlock: Its Place in the Silviculture of the Southern New England Forest.* Bulletin 12, Yale School of Forestry, 1924, p. 44.

HARDWOOD SWAMP TYPE

Excess moisture makes the cutting and hauling of forest products difficult and even impossible during certain seasons. Rarely does the ground freeze sufficiently to support the weight of heavy loads. When extremely cold weather does come it affords the best chance for logging operations.

Growth in the swamps is comparatively slow because of the poor drainage. The species—namely, red maple, elm, and black ash—predominating in the swamps are inferior in value to the better species on the uplands. Red maple is the chief commercial species in the hardwood swamp type. It is the best of the swamp species in rate of growth and ability to reproduce. These three handicaps, expensive logging, slow growth, and poor species, make impossible intensive forestry in the hardwood swamp type.

The stands in this type, just as on the uplands, exist in evenaged and unevenaged form. Evenaged stands reach commercial maturity without any treatment. Exceptions occur in the case of swamps which for some reason can be logged easily. Here thinnings (very desirable for the dense stands, especially of red maple) are made at intervals as described for the hardwood type. Only a small portion of the type falls into this class. Most of the evenaged stands are cut clear when 60 to 80 years of age for railroad ties, piling, and cordwood. Following the clear cutting, the new crop (partly sprouts and partly seedlings) springs up, though not always in the quantity desired. Woody shrubs frequently monopolize the ground under the old stand. Just how to get rid of this undergrowth and replace it with young trees is as yet unsolved.

The unevenaged stands receive a selection cutting as described under the hardwood type. Usually timber only is taken. Even the tops of the trees cut for timber are not always worked up into cordwood.

Eventually many of the swamps may be drained as a part of the development work in connection with the water supply. In some instances this has already been done. Drainage usually makes the land suitable for growing some of the upland species and thus removes the area from the hardwood swamp type.

PINE TYPE

Red pine and white pine are considered the best trees to favor in the pine type. The soils are suitable for good development of either of these two species. Other coniferous species have been planted only experimentally. Whether red or white pine will be the best species in the long run cannot be determined at this early date. Each has its good points. Both grow rapidly, produce valuable wood, and are easy to establish artificially. In addition red pine is favored because of its hardiness and its freedom from serious plant pests. White pine, while attacked by more dangerous plant pests, may produce a larger volume of forest products in a given time, and its wood has a somewhat higher technical value.

Since this type has been established artificially on old fields during the last thirty years (most of it during the last twenty), the stands of pine are not old enough to harvest. Hence the treatment so far has consisted of cultural operations designed to improve the young pine stands. A considerable outlay is made in the planting of the pine trees. In order to get the highest returns ultimately from the initial investment, a variety of cultural operations have been employed.

When the pine is planted, the effort is made to avoid areas already stocked with trees. This effort is not always successful, for young seedlings hidden in the grass are easily overlooked. Furthermore, fast-growing hardwoods like gray birch may establish themselves after the planting of the pine. The danger from the hardwoods comes when they grow faster than the pine and threaten to overtop and eventually cause the death of the pine. When this situation develops a release cutting is made (Plates 52 and 53). As the name implies, it releases the pine from the less valuable overtopping hardwoods which are cut. The material cut is occasionally merchantable for cordwood, but usually is too small to utilize.

A mixture of hardwoods with the pine improves soil conditions and assists in killing the side branches of the pine, thereby bettering the quality of the pine lumber secured. The elimination of all hardwoods is not attempted in the release cuttings. Ten to twenty per cent of the area in the pine type can advantageously remain in hardwoods established as single trees among the pine or as patches of brush and hardwoods which were never planted. In many of the plantations there is not at present a sufficient mixture of hardwoods.

Most of the pine type develops well without being overtopped by hardwoods. Release cuttings are needed on not over ten per cent of the area planted to pine in a given year. It takes from one-half to two days' (eight-hour day) labor per acre to make release cuttings in the pine type. Sometimes a second release cutting is needed on the same area before the pine establishes itself in dominant position. The small portion of the type planted on hardwood land around reservoirs receives from two to four release cuttings.

The terminal shoots on white pines often are attacked and killed by the grubs of the white pine weevil. Damage consists in the destruction of the last one or more years' growth on the main stem and reduction in the lumber value of the tree. One or more of the side branches on the top whorl turn upward and replace the original leader. A crook in the tree is caused where the side branch turns up. In a dense stand the branches may turn up very sharply and produce only a slight crook. In open stands the crook may constitute a serious deformity. A period of from eight to fifteen years from the time the trees are three feet in height until complete closure of the stand takes place is the time of greatest injury. Enough trees per acre to make a good timber crop must be brought through this period without being seriously weeviled. To accomplish this, each year in early summer when the grubs are working, the infested leaders are cut back to the first uninjured whorl. All these leaders are collected and burned. Many weevils are thus destroyed, and the amount of injury done in succeeding years is lessened. This procedure has resulted, under the local conditions, in producing white pine plantations containing a satisfactory number of trees unweeviled at least in the first 16-foot log. Two hundred per acre of such trees are considered adequate. The first 16-foot log contains a considerable part of the total volume of the tree. Furthermore, weeviling above this point occurs after the stand has closed and results in slighter crooks.

In 1927 the policy of pruning selected white and red pine trees (approximately 200 per acre) up to height of 17 feet was put into effect. Both live and dead limbs are cut. The pruning is started soon after the stand closes, usually when the plantation is ten to fifteen years of age, and is carried up to 17 feet by three or four operations each two to three years apart. By starting at this early age the knotty core in the center of the log can be kept small — 4 to 6 inches in diameter.

Pruning is done from the ground upward and is stopped each time at a point on the tree not higher than the point of contact with the crowns of adjoining trees. If this detail is observed, pruning of live limbs has no injurious effect on the vigor of the tree. The lumber produced in unpruned pine plantations where the trees are originally set six feet apart will be very knotty (Plate 54). It is believed that, as a result of pruning, the amount of clear lumber can be greatly increased.

As yet the plantations have not reached the age where they can be thinned at a profit. Pine fuelwood has practically no value in this region. Until the trees which should be removed reach a size suitable for lumber, thinnings will not be undertaken on a commercial scale. They can be started in the average stand when the plantation has been established twenty-five years. As yet only a few experimental thinnings have been made (Plate 55).

When the thinnings are started they will be of the type known as crown thinnings. The trees chosen for removal will be selected so as to free the crowns of the pruned trees. The policy will be to keep these pruned trees growing at a fast rate so as to produce a large 16-foot butt log containing clear lumber. The seriously weeviled trees will be taken out gradually in the thinnings (Plate 56).

Thinning in a given stand will be repeated at intervals of about ten years until the stand is ready to harvest. It is not necessary at this time to settle upon the age for reproducing the pine stands. The operation is far in the future. Probably it will be the best policy from all standpoints to allow the timber to grow until it is sixty to eighty years of age.

The pine plantations have been established on land which, though in recent years used for agriculture, was originally covered by a forest predominantly hardwood. It is to be expected that the planted pine will not be able to reproduce on this land in competition with the hardwood species which are sure to seed in under the pine as time passes. This will be evident as soon as thinnings are begun on a commercial scale. Eventually the pine plantations are likely to be converted into mixed stands composed of naturally reproduced pine, various hardwoods, and hemlock. Such stands will be an improvement over either the pure pine or hardwoods.

CEDAR SWAMP TYPE

Only one small cutting to remove dead cedar poles has been made in the small area of cedar swamps. Most and possibly all of the 59 acres in this type will be affected within relatively few years by drainage work to improve water supply conditions. If the swamps are drained, the cedar will be replaced by hardwood species and the type changed by natural means either to hardwood swamp or to the hardwood type. In their present condition the cedar swamps are difficult to log. Until all contemplated drainage projects are completed nothing will be done except to sell dead cedar when opportunity offers.

OPEN SWAMP

No operations are contemplated. If any open swamps are drained they can then be planted.

AGRICULTURAL LAND

So long as this land can be used to advantage for agricultural purposes it should be done. Since in protecting the watersheds, use of agricultural land often must be hampered by restrictions, these areas are apt to deteriorate in quality and eventually become unprofitable. They then go into the old field type and are available for planting with pines.

THE FINANCIAL ASPECT

The practice of forestry will prove to be profitable on the Eli Whitney Forest. One favorable factor of influence here is that interest and taxes on the investment in land and improvements cannot justly be charged against the forestry project. The land was bought and is held primarily for watershed protection. Taxes and interest must be paid regardless of whether forestry is practiced or not. Growing of tree crops affords the best way of securing an income from the lands and at the same time obtaining maximum protection. A somewhat similar situation exists for many landowners, other than water companies, in a region such as southern Connecticut. Because of the prevalence of bare land or young age classes and the corresponding scarcity of merchantable timber, it is impossible to make the practice of forestry return an *immediate* profit on the average tract in this region.

When the work was initiated, it was hoped that the expenses of reforesting the bare lands and of protecting and improving the entire forest could be met out of current income from sales of wood and timber. Up to date this has been accomplished. The continued rapid buying of new lands, owing to the necessary development of additional water supply resources, keeps the Eli Whitney Forest still in the stage of early organization and development. Until the planting of bare lands is completed, a balancing of current receipts and expenditures is all that can reasonably be expected. Once this stage is well past and the middle-aged stands commence to reach merchantable size, expenses will be lessened, a gradual increase in the cut of timber can be made, and enlarged income will result.

THE MALTBY AND SALTONSTALL DIVISIONS AS DEMONSTRATION AREAS

The Maltby and Saltonstall divisions were selected in 1929 for use as demonstration areas illustrating forestry as practiced on the Eli Whitney Forest. A revised timber estimate, growth study, map, and detailed compartment descriptions were prepared for each. Maltby and Saltonstall were selected rather than any of the other divisions for several reasons. They have both been under forest management since 1907 and can be quickly reached from the city either by automobile or trolley. Each furnishes a contrast to the other in physiographic and forest conditions and in methods of treatment. Combined, they illustrate nearly the whole range of operations on the Eli Whitney Forest.

Copies of the two maps appear opposite pages 28 and 30. The compartment descriptions similar to the sample on pages 27 and 28 are on file.

The estimate of standing timber and growth on the whole forest, presented in Tables V and VI, is based on relatively extensive surveys for portions of the lands which have been owned for only a few years. Additions have been made to the forest so rapidly during recent years that forest organization has not kept pace with the buying. The earlier estimates of timber and study of growth were less intensive than studies which are later made on all divisions.

In order to show the character of the estimates of wood and timber and of growth that are planned for the whole property, the figures secured in 1929 for Maltby and Saltonstall are summarized in the following tables. The area of the forest types by age classes is also shown as being of interest in connection with the volume and growth data.

It will be noted that in Tables VII and VIII three products—cubic feet, lumber in feet, board measure, and cordwood—are shown instead of the lumber alone as in Table V. The cubic feet are given as the best measure of the total wood volume in the trees. It has value at present principally for scientific purposes. The lumber and the cordwood combined represent the merchantable portion of the trees. Cordwood is taken from the tops of trees suitable for lumber and also includes the entire stem of trees too small for lumber. In the cordwood estimate broad-leaved species only are included, as the principal conifers, hemlock, and pine have very little value as fuelwood.

Tables IX and X are more detailed than Table VI, since the growth is given separately by age classes. A more intensive method than that applied in Table VI was used to secure the growth on the Maltby and Saltonstall divisions. Measurements of the growth in diameter were taken by borings on trees of various ages and sizes. Tallies of the total number of trees in each group also were obtained. The annual growth in volume as given in Tables IX and X was derived from these data. A better idea is secured in this way as to what portion of the growth might be available for cutting within the next few years. Evidently growth put on by young and middle-aged stands cannot be harvested at once but should be allowed to accumulate and build up the forest capital. In the older age classes and in the unevenaged stands the growth is more likely to be available for immediate cutting.

TABLE VII. AMOUNT OF STANDING WOOD AND TIMBER IN THE MALTBY DIVISION

	FOREST TYPE														
	Hardwood			*Hardwood swamp*			*Hemlock-hardwood*			*Pine*			*Totals*		
Age class	*M** *Cu.ft.*	*M** *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*
1-20	55	17	601	8		80				123	309	98	186	326	779
21-40	317	283	3,280	10	6	109				22	60	41	349	349	3,430
41-60	126	428	958	13	38	78							139	466	1,036
61-80	124	512	513	6	15	47							131	527	560
81-100	3	17	5										3	17	5
Unevenaged	14	41	87				3	20	4				17	61	91
Totals	639	1,298	5,444	37	59	314	3	20	4	145	369	139	825	1,746	5,901

* All figures for both cubic feet and feet, board measure, are shown to the nearest 1,000 feet.

TABLE VIII. AMOUNT OF STANDING WOOD AND TIMBER IN THE SALTONSTALL DIVISION

	FOREST TYPE														
	Hardwood			*Hardwood swamp*			*Hemlock-hardwoods*			*Pine*			*Totals*		
Age class	*M** *Cu.ft.*	*M** *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*	*M* *Cu.ft.*	*M* *Ft.B.M.*	*Cords*
1-20	70	87	522	1	1	12				222†	671†	192†	293	759	726
21-40	166	267	1,175	13	18	90				39	104	51	218	389	1,316
41-60	121	436	594	17	20	173	52	200	221				190	656	988
61-80							18	88	36				18	88	36
81-100							14	84	10				14	84	10
Unevenaged	382	1,407	1,820				305	1,291	798				687	2,698	2,618
Totals	739	2,197	4,111	31	39	275	389	1,663	1,065	261	775	243	1,420	4,674	5,694

* All figures for both cubic feet and feet, board measure, are shown to the nearest 1,000 feet.

† 11-20 years.

TABLE IX. ESTIMATED ANNUAL GROWTH IN LUMBER IN THE MALTBY DIVISION

	FOREST TYPE				
Age class	*Hardwood*	*Hardwood swamp*	*Hemlock-hardwood*	*Pine*	*Totals*
	Annual growth in feet, board measure				
1-20	4,500	100		186,400*	191,000
21-40	44,000	1,000		27,900	72,900
41-60	38,700	3,100			41,800
61-80	24,300	1,400			25,700
81-100	600				600
Unevenaged	4,700		1,000		5,700
Totals	116,800	5,600	1,000	214,300	337,700

* Divided into 300 feet, board measure, 1-10 years and 186,100 feet, board measure, 11-20 years.

TABLE X. ESTIMATED ANNUAL GROWTH IN LUMBER IN THE SALTONSTALL DIVISION

	FOREST TYPE				
Age class	*Hardwood*	*Hardwood swamp*	*Hemlock-hardwood*	*Pine*	*Totals*
	Annual growth in feet, board measure				
1-20	11,900	300		314,000*	326,200
21-40	34,000	2,200		47,600	83,800
41-60	29,500	2,800	13,000		45,300
61-80			4,900		4,900
81-100			3,900		3,900
Unevenaged	83,200		79,100		162,300
Totals	158,600	5,300	100,900	361,600	626,400

* 11-20 years.

TABLE XI. AREA IN ACRES OF THE FOREST TYPES BY AGE CLASSES IN THE MALTBY DIVISION

	FOREST TYPE					
Age class	*Hardwood*	*Hardwood swamp*	*Hemlock-hardwood*	*Pine*	*Old field*	*Totals*
1-20	229.0	51.7		328.9*		609.6
21-40	345.4	11.5		23.5		380.4
41-60	115.1	8.7				123.8
61-80	96.0	3.4				99.4
81-100	1.9					1.9
Unevenaged	13.2		2.7		.7	16.6
Totals	800.6	75.3	2.7	352.4	.7	1,231.7

* Divided into 170.9 acres 1-10 years and 158 acres 11-20 years.

TABLE XII. AREA IN ACRES OF THE FOREST TYPES BY AGE CLASSES IN THE SALTONSTALL DIVISION

	FOREST TYPE					
Age class	*Hardwood*	*Hardwood swamp*	*Hemlock-hardwood*	*Pine*	*Old field*	*Totals*
1-20	119.5	2.3		398.4*		520.2
21-40	148.9	9.1		25.7		183.7
41-60	81.1	8.5	29.1			118.7
61-80			9.0			9.0
81-100			3.8			3.8
Unevenaged	268.2		204.7		9.2	482.1
Totals	617.7	19.9	246.6	424.1	9.2	1,317.5

* Divided into 76.3 acres 1-10 years and 322.1 acres 11-20 years.

ILLUSTRATIONS

PLATE 1. THE OLD FIELD TYPE

OLD field partially stocked with cedar and low juniper. Hardwood seedlings, chiefly hard maple, ash, and cherry, are starting in small quantities. This area was planted with 3-year-old red pine transplants in the spring of 1928. The pines are hidden in the grass and do not show. See Plate 12.

North Branford, Island in the Reservoir.
1929.

PLATE 2. OLD FIELD STAND REVERTING TO HARDWOODS

An old field stand of hardwoods and cedar which is reverting to the hardwood type. This picture shows a more advanced stage of the conversion of an old field to the hardwood type. The hickory in the center is 6 inches in diameter and 50 feet high. This hickory, together with the white oak on the left, seeded in at the same time as the birch and cedar. The birch has about reached its maturity and is going to pieces. Large numbers of white oak seedlings have started underneath. At the left of the picture these are shown 6 to 8 feet in height, while elsewhere they are of seedling size. There are also some ash and maple seedlings present. The birch is about 40 years of age. Soil, medium to poor.

West River, Compartment 4.
February, 1929.

PLATE 3. THE OLD FIELD TYPE, PURE GRAY BIRCH

An old field stand of gray birch approximately 20 years of age. The larger tree in the left foreground is an aspen. The gray birch with the calipers is 3 inches in diameter. A few trees are a little larger, but this is the average maximum size. Note the axe in the foreground which is standing beside a white oak seedling. The process of reversion to the hardwood type has already started, as is attested by the presence of various hardwood seedlings such as the one shown. Many birch trees have already died.

Maltby, Compartment 21.
January, 1929.

PLATE 4. AN UNEVENAGED STAND OF THE HARDWOOD TYPE

An unevenaged stand of mixed hardwoods originally established on an old field. The evidences of this origin are seen in the few living gray birch, the rotting stumps of other gray birch trees, and an occasional red cedar. The red oak in the center is 19 inches in diameter and 85 feet in height. The other trees range downward in size to young seedlings. The species found beside the oak are black birch, hickory, ash, gray birch, and cedar. Most of the small reproduction is white ash. The present stand contains 6,800 feet, board measure, and 8 cords per acre.

West River, Compartment 6.
February, 1929.

PLATE 5. SEVENTY-YEAR-OLD HARDWOOD ON MEDIUM SOIL

A STAND of mixed hardwood, principally oak, on a rocky plateau. The site ranges from medium to poor. Red oak, chestnut oak, white oak, soft maple, hard maple, chestnut, basswood, black birch, and hemlock form the stand. The tree calipered is a red oak sprout 13 inches in diameter. Ages are somewhat irregular, but on the whole the stand approaches evenaged condition. The larger oaks seen are approximately 70 years of age.

West River, Compartment 1.
March, 1929.

PLATE 6. THE HARDWOOD TYPE, EVENAGED ON EXCELLENT SOIL

An evenaged stand of mixed hardwoods on first quality soil. The tree being calipered is 10 inches in diameter. The principal species are whitewood seen in the left center, a basswood tree on the extreme left, ash, hard maple, and sycamore. This stand is between 50 and 60 years of age and is from 50 to 80 feet in height. It contains 5,400 feet of lumber and 8 cords of wood per acre. There is very little hemlock present, although a few seedlings are shown coming in.

North Branford, Compartment 8.
February, 1929.

PLATE 7. A DENSE STAND OF FORTY-YEAR-OLD HARDWOOD

A MIXED hardwood stand on a good site. The stand needs thinning. The tree with the calipers is a red oak of ideal form. It is 9 inches in diameter, approximately 32 feet to the first limb, with a total height of 60 feet. Age is estimated to be about 40 years. The width of crown is 25 feet. Note the rapid growth of the terminal twigs.

North Madison, Compartment 21.
February, 1929.

PLATE 8. HEMLOCK REPRODUCTION IN THE HEMLOCK-HARDWOOD TYPE

Reproduction of hemlock in the foreground which is developed on the edge of a woods road under the cover of the large oak in the center. This red oak is 20 inches in diameter and is estimated to be 80 years of age. The hemlock has all originated within the last 5 to 10 years. Some hardwood seedlings have started along with the hemlock, but this patch is an illustration of the fact that hemlock will sometimes start either alone or sufficiently ahead of the hardwoods to dominate the opening. The forest in the background will be developed into an unevenaged stand with oak and hemlock as the predominant species.

Saltonstall, Compartment 21.
January, 1929.

PLATE 9. HEMLOCK-HARDWOOD TYPE, AN EVENAGED GROUP OF HEMLOCK AND BLACK BIRCH

An evenaged 55-year-old group of hemlock. This small stand originated on an old pasture. It represents one of the most regular forms of the hemlock-hardwood type. A few black birch occur in the stand. The tree with the calipers is 6 inches in diameter and 55 feet in height. This stand was measured in 1923 and found to contain 13,400 feet, board measure, of lumber per acre. The area is a site of medium quality.

Saltonstall, Compartment 28.
February, 1929.

PLATE 10. AN OLD STAND OF THE HEMLOCK-HARDWOOD TYPE

THIS picture is taken on the summit of Saltonstall ridge alongside the trail which crosses from the Foxon flagpole to the head of the lake. The trail runs through the picture a little way beyond the man. A selection cutting was made on top of Saltonstall ridge in 1919–1920. At that time a belt 50 feet wide on each side of the trail was reserved uncut. Conditions both inside and outside the reserved belt are seen. The man is standing about 10 feet inside the reserved belt. The right side of the picture shows conditions on the cutover area. It will be noted that the ground is covered with hemlock and black birch seedlings. These have become established since the cutting. In the reserved belt no reproduction has started. The timber averages about 80 feet in height and about 12,000 feet, board measure, per acre. The stand is somewhat irregular in age. Probably the youngest is not over 100 years old, while the largest hardwood and hemlock is between 175 and 200 years.

Saltonstall, Compartment 31.
February, 1929.

PLATE 11. THE HEMLOCK-HARDWOOD TYPE IN UNEVENAGED FORM

The hemlock occur either as scattered trees seen in the foreground or as small clumps seen in the background. The distribution of sizes is shown in the picture. This stand is on the southern slope on a trap rock ridge. A selection cutting removing the largest hemlock and a few of the larger hardwood trees is needed. The hardwoods range in height from 50 to 70 feet, while the hemlock is 70 to 80 feet tall. The present yield is estimated at 9,800 feet, board measure, and 8 cords of wood per acre. The oldest hemlock is estimated to be around 150 years of age.

North Branford, Compartment 8.
February, 1929.

PLATE 12. PINE RECENTLY ESTABLISHED ON AN OLD FIELD

OLD field planted with 3-year-old red pine transplants in the spring of 1928. Two young red pine plants can be seen by the axe and caliper in the foreground. See Plate 1.

North Branford, Island in the Reservoir.
1929.

PLATE 13. WHITE PINE EIGHT YEARS AFTER BEING PLANTED

A PLANTATION of white pine which has not quite closed. This plantation was made in the spring of 1921 with 3-year-old transplant stock. It was established on an old meadow of good quality soil. It has been protected against injury by weevils by cutting off the infested leaders early each summer and burning them. Very little evidence of weevil damage is shown. The trees range from 6 to 9 feet in height. In the middle may be noted a gray birch seedling 9 feet in height. Other hardwoods have seeded in to some extent among the pine, but as yet no release cutting has been necessary. This stand will be ready for the initiation of pruning in less than five years.

Maltby, Compartment 36.
January, 1929.

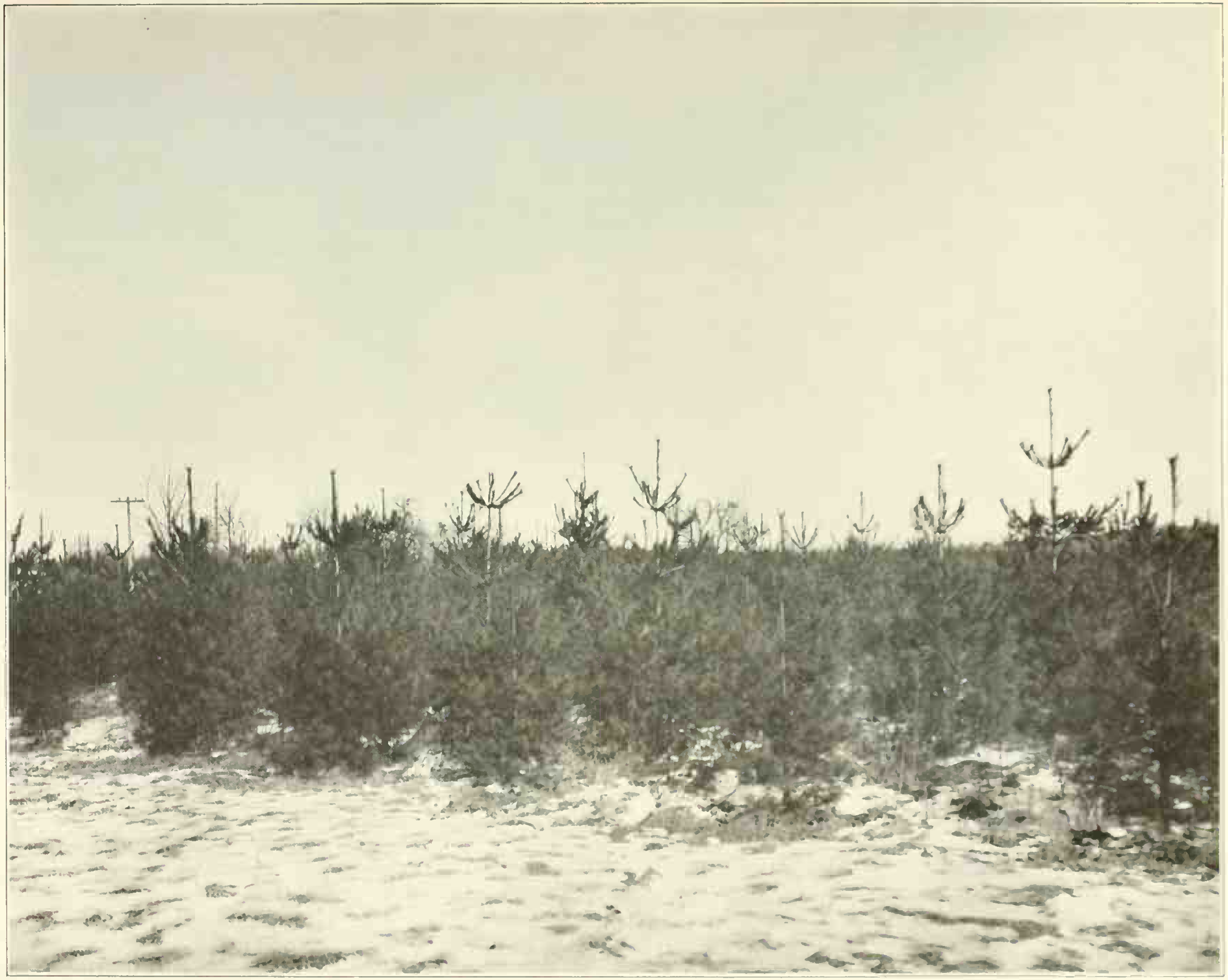

PLATE 14. A YOUNG PLANTATION OF RED PINE

A RED pine plantation just closing and ready for its first pruning. This plantation was made in 1919 and spaced 6 x 6 feet. It is on average soil. The plantation was for a number of years grazed by dairy cattle. Trees range from 9 to 12 feet in height. All the live limbs can be pruned off except the last three to four whorls. On the average a distance of 3 feet up from the ground can be pruned.

West River, Compartment 8.
February, 1929.

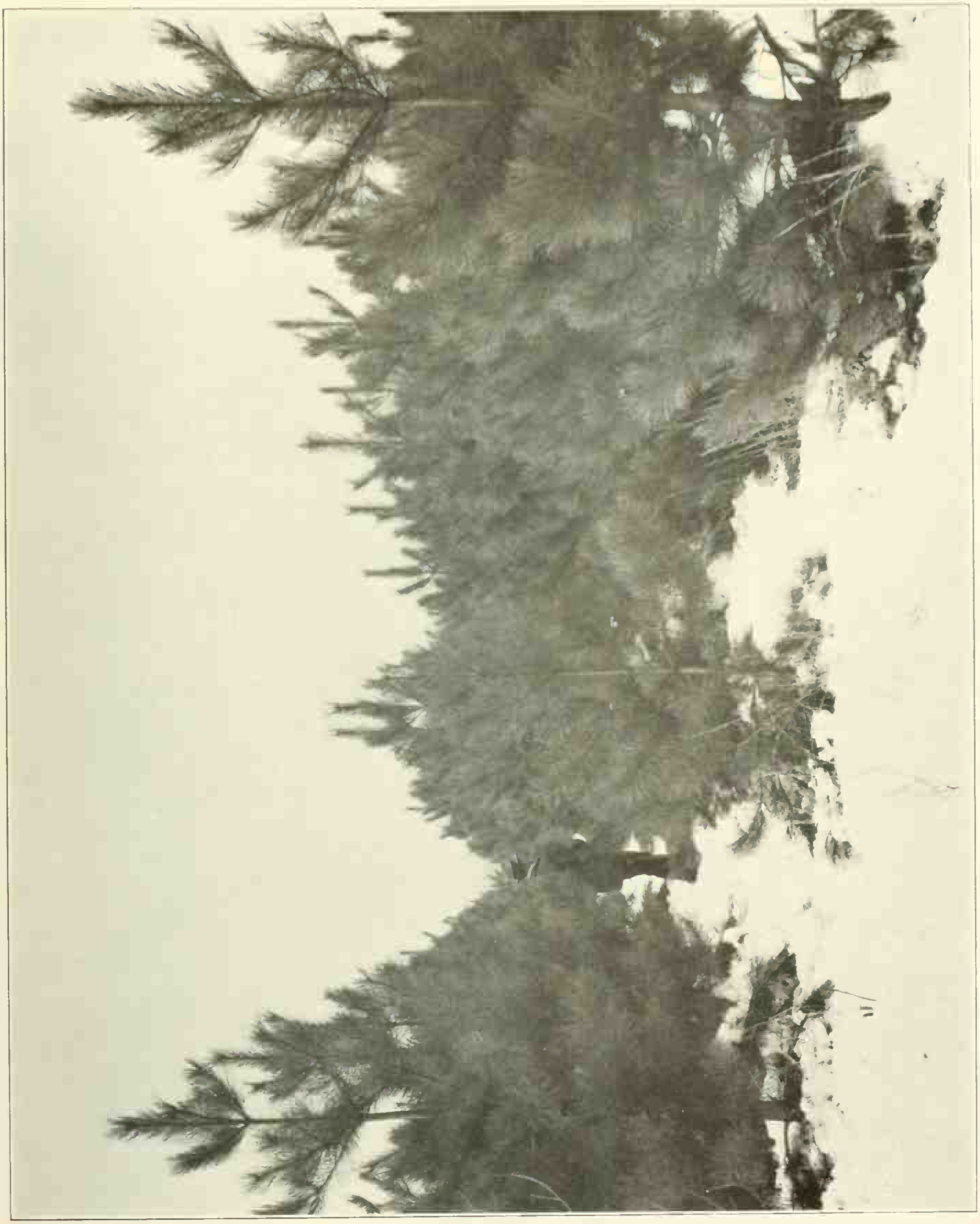

PLATE 15. RED PINE PLANTATION ESTABLISHED FIFTEEN YEARS

A VIEW of a red pine plantation established in 1914. While the plantation is densely stocked and completely closed inside, yet along the roadway the live limbs have been retained to the ground. The largest trees are 5 inches in diameter and 25 feet in height.

West River, Compartment 7.
February, 1929.

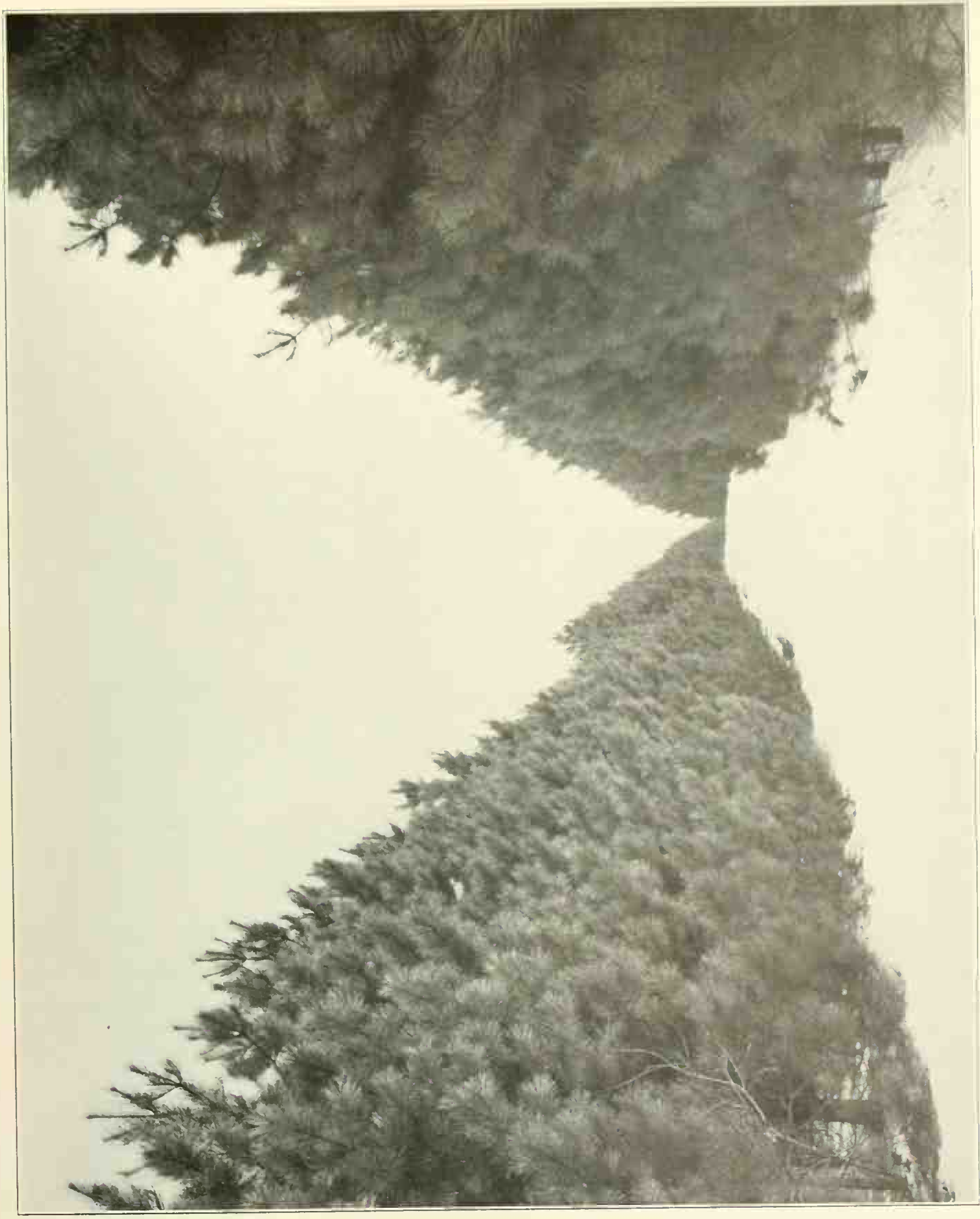

PLATE 16. THE HARDWOOD SWAMP TYPE

This stand is growing on a wet swamp and shows very slow growth and poor development. It is 80 to 85 years of age. The principal species are soft maple, black ash, and elm. The stand was thinned in 1916 removing 9 cords per acre. Calipers are on a tree which is at present 7 inches in diameter. In 1916 it was 6 inches in diameter. Note the undergrowth of woody shrubs and swamp grass which is characteristic of the swamp sites. The present stand contains 2,400 feet, board measure, per acre and 12 cords of wood.

Maltby, Compartment 10.
January, 1929.

PLATE 17. A SMALL PORTABLE MILL

OPERATED by a 20 to 30 horsepower International tractor. The mill is easily moved and set up. A minimum crew of two men is needed to operate the mill. The circular saw used is 52 inches in diameter and cuts a quarter-inch saw kerf. Rollway for logs is seen at the right. With the outfit as shown they should saw 4,000 to 5,000 feet, board measure, of lumber per day. The mill is set up beside the road just south of Compartment 40.

Saltonstall.
August, 1929.

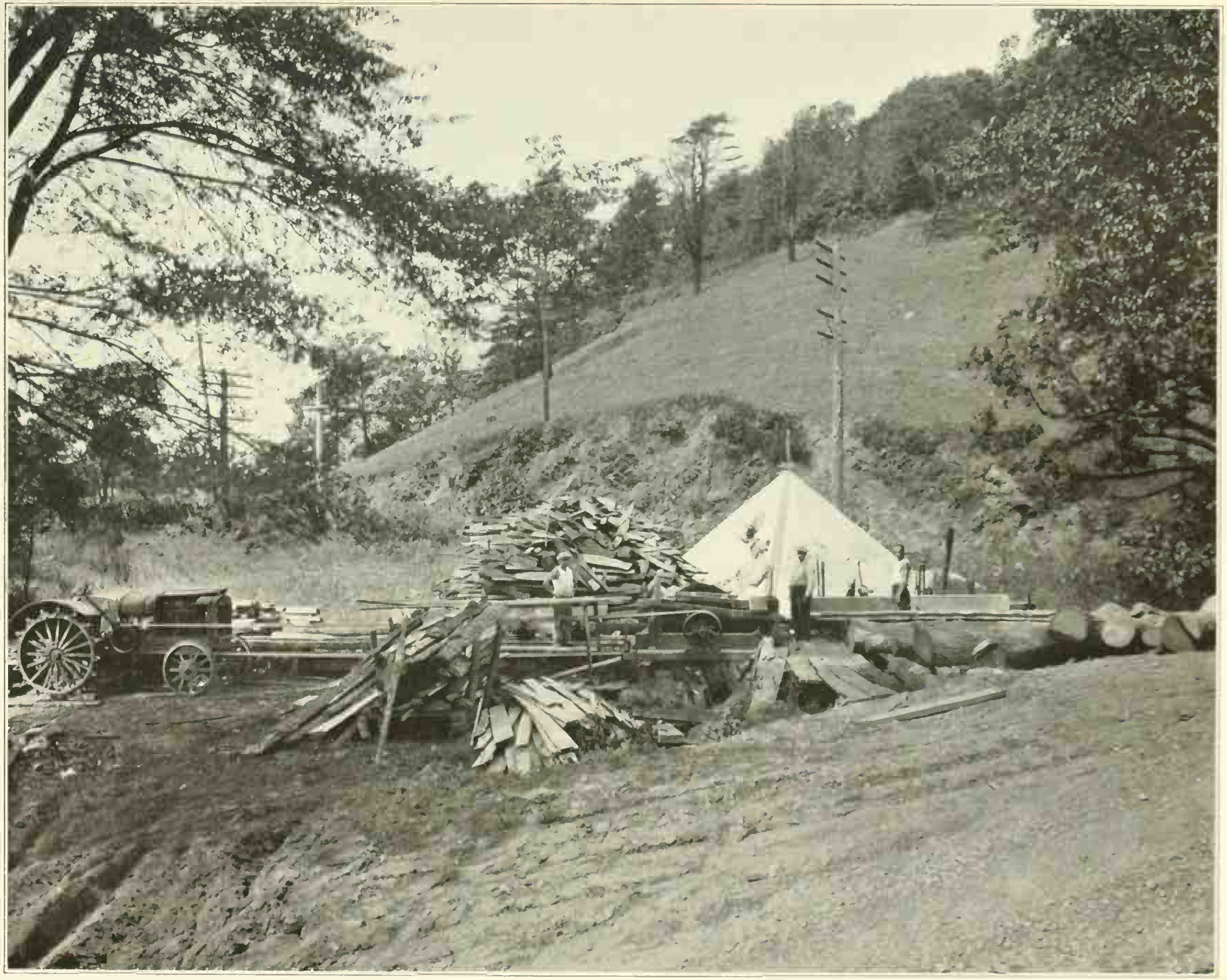

PLATE 18. ANOTHER VIEW OF A PORTABLE MILL

THE same mill as shown by Plate 17, but seen from the tail end. The better grade material, which is chiefly oak, is put into square-edged plank. The lower grade logs, both of oak and various hardwood species, go into ties. Some of the ties and plank are shown in the foreground. The cut-off saw at the right can be connected with the tractor.

Saltonstall.
August, 1929.

PLATE 19. WOOD YARD ON THE MALTBY DIVISION

A YARD for handling cordwood at retail. At the right is shown a portable gasoline engine with equipment for sawing cordwood into short lengths. In the background the 5-foot wood as brought in from the forest is shown. This is sawn into two lengths, 20 inches, as shown in the pile on the left, for firewood, and 12 inches, as shown in the pile in the center, for burning in stoves and furnaces and for kindling. Each year 100 to 200 cords of such wood are cut on the Maltby division and sold at retail. The wood is hauled into this yard in 5-foot lengths by teams, cut into shorter lengths, and then delivered by truck to consumers in the city.

Maltby, Compartment 3.
January, 1929.

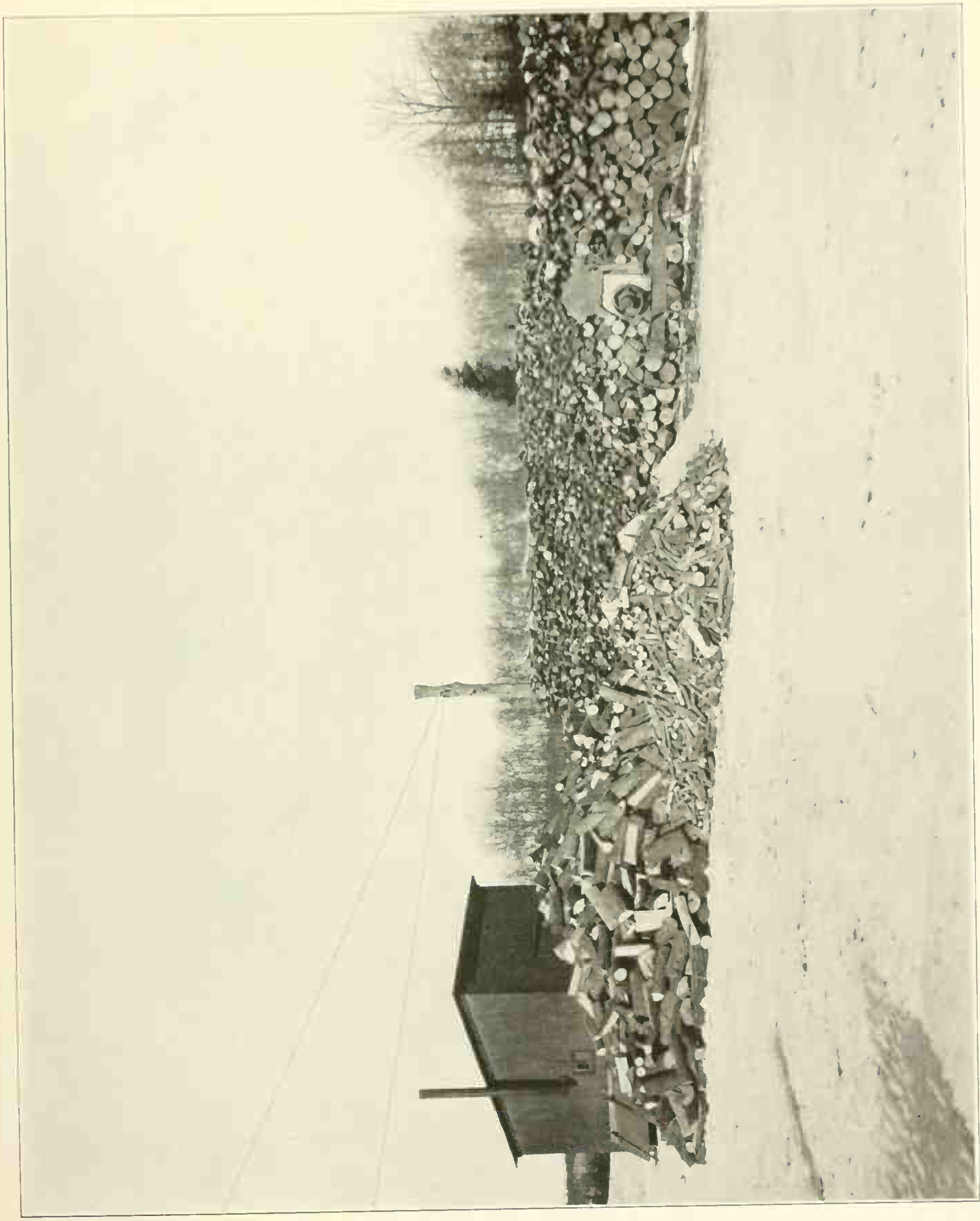

PLATE 20. AN OAK RUINED BY STRUMELLA CANKER

A close-up view of a 9-inch red oak attacked by strumella canker. This was a healthy co-dominant tree. The caliper arm, over 20 inches in length, gives an idea of the length of the canker, which is approximately double the length of the caliper arm. In width the canker measured 12 inches. The tree was swollen to a greater size than its breadth at breast high. It is likely that this oak will break off inside of the next year.

North Madison, Compartment 30.
February, 1929.

PLATE 21. A WELL-KEPT WOODS ROAD

An example of a woods road cleared out to serve the purposes of transportation for forest products and quick access in case of fire. The trees bordering this road are white pine and were planted in 1912. The trees immediately adjacent to the road were pruned in 1928 so as not to interfere with traffic. In addition, some trees in from the road have been pruned to produce a clear butt log. The tree with the caliper is 8 inches in diameter.

Saltonstall, Compartment 7.
January, 1929.

PLATE 22. A FIRE LINE

A fire line protecting a pine plantation where it adjoins the public highway. This is a narrow line kept free of inflammable material. Originally constructed by plowing, it is now maintained by harrowing. Note the scattered pine needles on the line. Before these make a continuous cover the line must be harrowed again. On soils capable of being plowed this type of fire line is effective.

Mill River, Compartment 2.
1929.

PLATE 23. A RAILROAD FIRE LINE

White pine plantation on the east side of Lake Saltonstall established in 1912. The present volume is 2,800 feet, board measure, per acre, and the average height of the dominant trees is 29 feet. The railroad track is the shore line of the New York, New Haven, and Hartford Railroad. The section shown has a considerable grade, and coal-burning locomotives are used. It has been necessary to establish fire lines on each side of the right of way. In this picture the pine on the right-hand side of the track shows particularly well. First may be seen the land next to the track on the railroad right of way, then comes the line of poles nearly on the boundary of the railroad land. Adjoining is a plowed strip, then comes a wide strip of burned-over meadow, and finally a plowed strip approximately 6 feet wide next to the pine. The total width of the fire line itself, outside of the railroad company's right of way, is approximately 100 feet. This line has been effective in preventing the entrance into the pine plantations of fires which start on the bank close to the track.

Saltonstall, Compartments 3 and 5.
February, 1929.

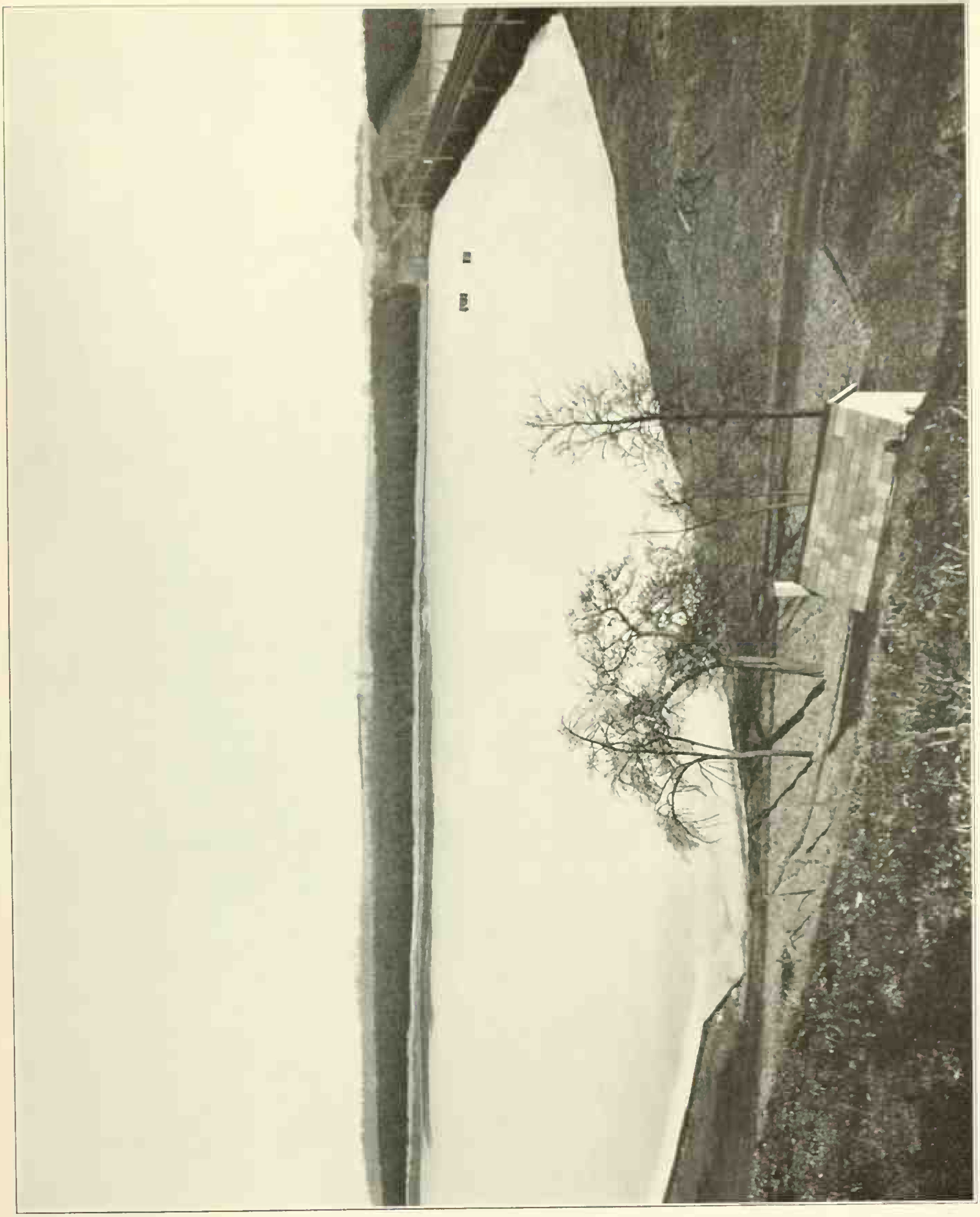

PLATE 24. AN EXCELLENT PROTECTION FOREST AFTER A LIGHT CUTTING

A LIGHT selection cutting in the hardwood type removing 1,300 feet, board measure, per acre. Five thousand five hundred feet, board measure, per acre are left.

North Madison, Compartment 24.
1929.

PLATE 25. THINNED HARDWOOD STAND SHOWING THE AMOUNT OF SLASH LEFT

A THINNING in a 40-year-old hardwood stand. The amount cut was 15 cords per acre. There remain standing 3,800 feet, board measure, and 8 cords of wood per acre. The best trees in the hollow are 70 feet in height. The tree with the calipers is a chestnut oak 9 inches in diameter and 55 feet high. Red oak, chestnut oak, white oak, whitewood, yellow birch, and beech form the stand in the hollow, but on the slope the stand is mostly red and chestnut oak. Note the slash still retaining the leaves. This area was cut in the summer and fall of 1928. Except in the hollow the site is a dry talus rock slope. Note the small part of the area which is covered with slash.

West River, Compartment 1.
February, 1929.

PLATE 26. A WHITE OAK STAND RECENTLY THINNED

A HEAVILY-STOCKED, almost pure stand of white oak seedlings 40 years of age. This area was thinned in the spring of 1928. There are more than 300 oaks per acre remaining. Approximately 8 cords of wood per acre were cut, and the remaining stand contains 13 cords and 1,600 feet, board measure, per acre.

The tree calipered is 7 inches in diameter. The best trees are 50 to 60 feet in height. The stump with the axe sticking into it is that of a black oak 9 inches in diameter. This was one of the largest trees cut in the thinning. In addition to the white oak there are a few red and black oak, hard maple, ash, and hickory trees in the stand.

West River, Compartment 8.
February, 1929.

PLATE 27. FIRST THINNING IN A FORTY-YEAR-OLD HARDWOOD STAND

THIS was a combination of a low thinning and salvage cutting for chestnut. Ten cords per acre were cut, and 8 cords per acre remain standing. Soil ranges from poor on the ridges to good in the hollows. Height of stand is 40 to 50 feet.

Maltby, Compartment 14.
1929.

PLATE 28. A SIXTY-YEAR-OLD THINNED STAND OF HARDWOOD ON FIRST QUALITY SOIL

A stand of whitewood, red oak, and ash on excellent soil, which was thinned in 1925. Fourteen cords of wood per acre were removed. There now remain 6,700 feet, board measure, per acre. The stand is evenaged and is approximately 60 years old. The heights range from 60 to 80 feet. In the background the land rises in a steep rocky slope to the summit of the West Rock ridge.

West River, Compartment 1.
February, 1929.

PLATE 29. A FIRST THINNING IN A MIXED HARDWOOD STAND SIXTY YEARS OLD

NOTE the brush left in various parts of the area, particularly in the left foreground. Such brush soon rots and is not a serious fire menace. Approximately 12 cords per acre were cut. The remaining stand contains 6,000 feet, board measure, per acre. The trees range from 60 to 80 feet in height. The soil ranges from good in the foreground to medium in the background.

West River, Compartment 8.
1929.

PLATE 30. HARDWOOD TYPE AFTER TWO THINNINGS

This is a 65-year-old mixed hardwood stand on best quality soil. The area has been thinned twice, first in 1912, removing 8 cords of fuelwood per acre, and again in 1925, removing 6 cords of fuelwood per acre. The trees in the mixture are beech, yellow birch, white ash, white oak, red oak, and hard maple. Hardwood reproduction of seedling origin is slowly being established in this stand. There are at present a good many sprouts from the stumps of trees cut in the two thinning operations. Present stand contains 3,200 feet of lumber.

This view is taken on permanent sample plot 64. The calipered tree is a beech 6 inches in diameter.

Maltby, Compartment 11.
January, 1929.

PLATE 31. OAK AND HICKORY REPRODUCTION

Reproduction established as a result of thinnings and shelterwood cuttings. The final cutting was made in 1921, and the earlier cuttings extended over a period of approximately 20 years preceding this time. All the trees in this picture are seedlings or seedling sprouts which originated in advance of the final cutting. The species in the picture are red oak, scarlet oak, and hickory. Several of the hickories can be plainly distinguished by their buds. Note that two of these hickories are among the dominant trees. This is characteristic of early stages in the life history of mixed hardwood stands on upland sites. Later on, the hickories will drop to a subordinate position, being unable to grow in height as fast as the oaks on a site of this character. The area shown is medium quality soil.

Maltby, Compartment 5.
January, 1929.

PLATE 32. WHITE OAK REPRODUCTION

Reproduction secured under a shelterwood method. Final cutting was made in 1921. Most of the reproduction in this picture is white oak. Practically all the trees in sight are of this species, with the exception of one or two red maple seen in the background. The white oak reproduction is either seedling or seedling sprouts in origin and ranges from 5 to 10 feet in height, although some overtopped seedlings are considerably lower. There are occasional black oaks in the stand.

Maltby, Compartment 8.
March, 1929.

PLATE 33. REMOVAL OF A MATURE STAND IN TWO REPRODUCTION CUTTINGS

THE STAND BEFORE THE FIRST CUTTING

A SHELTERWOOD cutting in an approximately evenaged group 80 to 100 years of age. The blazed trees will be removed. The oak with the calipers is one of the trees which remains. It is 15 inches in diameter. Enough of the old timber will remain to furnish adequate seed trees to restock the area. Already, as the result of a thinning made in 1911–12, considerable reproduction has started. While much of this consists of red maple seedlings and sprouts, there are also mixed in with the maple many seedlings of the more valuable hardwoods. The timber is 60 to 80 feet in height and 80 to 85 years of age. Five thousand seven hundred feet, board measure, per acre of lumber will be removed, leaving 4,200 feet, board measure, standing. See Plate 34 for the same area after the cutting.

Saltonstall, Compartment 40.
February, 1929.

PLATE 34. REMOVAL OF A MATURE STAND IN TWO REPRODUCTION CUTTINGS

THE STAND AFTER THE FIRST CUTTING

THE same area as shown in Plate 33, but after the blazed trees have been removed. As soon as enough seedlings start in the openings created by this cutting to complete the restocking of the area the remaining old timber can be removed.

Saltonstall, Compartment 40.
December, 1929.

PLATE 35. A SIXTY TO EIGHTY-YEAR-OLD HARDWOOD STAND READY FOR THE ESTABLISHMENT OF A NEW CROP

WITHIN the next 20 years this stand should be replaced with a young crop. While there are many large oaks capable of bearing seed, very little oak reproduction has yet appeared. There should eventually be an excellent reproduction of oak on this area.

A thinning was made in 1907–08, removing 6 cords of wood per acre. Another cutting, taking out the dead chestnut, was made in 1915. This removed 10 cords per acre. The volume now is estimated as 11,000 feet, board measure, and 9 cords of wood per acre.

At the present time beech has formed an understory over part of the area, and shrub growth has stocked most of the balance. The oak calipered is 13 inches in diameter. The stand is mostly red oak with some scarlet, black, and white oaks. Beech, hard maple, and hickory predominate among the small trees in the understory.

Maltby, Compartment 11.
March, 1929.

PLATE 36. TWENTY-YEAR-OLD CHESTNUT OAK STAND ON GOOD SOIL

STAND of chestnut oak reproduction. These seedlings and seedling sprouts have originated naturally under conditions approximating a shelterwood cutting within the last twenty years. Stumps of the mother trees are seen in the right background. The stand is fully stocked, containing 6,500 trees per acre. Maximum height is 30 feet.

Saltonstall, Compartment 21.
January, 1929.

PLATE 37. TWENTY-YEAR-OLD RED OAK STAND ESTABLISHED BY PLANTING ACORNS

In the foreground is shown a plantation of red oak established in 1909 on a site of medium quality. This was made by planting acorns at intervals of 6 x 6 feet. Two or three acorns were put in a hole. The tree calipered is 4 inches in diameter and approximately 30 feet high.

West River, Compartment 8.
February, 1929.

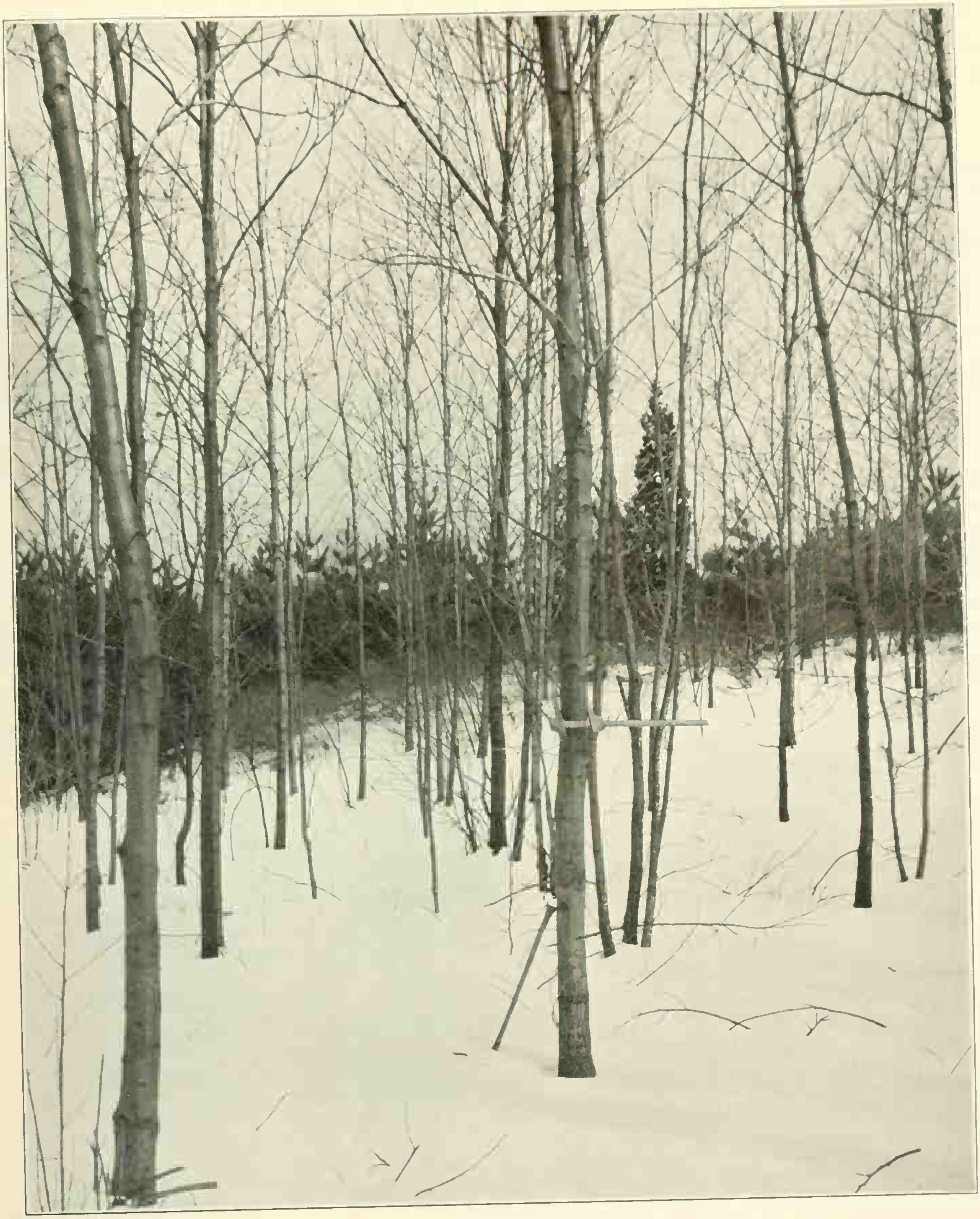

PLATE 38. SHRUB UNDERGROWTH BENEATH THINNED STAND

An 80-year-old stand which has been thinned several times in the last twenty years. A dense undergrowth of shrubs has developed, principally viburnum and dogwood. Scattered hardwood seedlings can be found among the shrubs. In this picture white oak, red oak, hickory, and whitewood seedlings can be seen. This stand contains 7,200 feet, board measure, per acre.

Maltby, Compartment 11.
1929.

PLATE 39. CLUMP OF RED OAK SPROUTS WITH UNDERSTORY OF SHRUBS AND TREE SEEDLINGS

Two sound red oak sprouts 15 and 16 inches in diameter at breast high. These trees are approximately 80 years of age. A large part of the undergrowth seen consists of viburnum and other shrubs. There are, however, many tree seedlings in the mixture. A 4-foot-high whitewood seedling can be seen in the left foreground. There are several small ash, maple, and oak seedlings on the ground. Two thinnings have been made, one in 1907–08 and the other in 1914.

Maltby, Compartment 11.
1929.

PLATE 40. A SELECTION CUTTING IN AN EVENAGED HARDWOOD STAND

As a result of the cutting the stand will become unevenaged. The hollow in the center is occupied by a thick group of black, red, white, and chestnut oaks, with a black oak and chestnut oak slope in the background. The quality of soil is excellent in the hollow. The best trees are 90 feet in height. Most of them range from 60 to 80 feet. The red oak calipered is 11 inches in diameter. The man is standing beside a black oak stump. This is a relatively heavy stand, containing after the cut 6,900 feet, board measure, and 5 cords per acre; 6,000 feet, board measure, and 7½ cords per acre were removed in the cut. The trees cut were 70 years old.

North Madison, Compartment 24.
February, 1929.

PLATE 41. UNEVENAGED HARDWOOD STAND MARKED FOR A SELECTION CUTTING

THE trees blazed will be removed. The tree in the center with the calipers is 16 inches in diameter and 70 feet in height. This cutting removes in some cases a group of larger trees, as in this instance, and sometimes only single large trees. Most of the small stems in the foreground are white ash seedlings. The center of the picture shows a low swale where moisture conditions are fairly good. The stand per acre before cutting is 6,000 and after cutting will be 3,500 feet, board measure. Compare with Plate 42, which shows the same area after the selection cutting. A cutting in the nature of a salvage cutting was made throughout this stand in 1911–12, removing a heavy cut of cordwood.

Saltonstall, Compartment 37.
February, 1929.

PLATE 42. UNEVENAGED HARDWOOD STAND AFTER A SELECTION CUTTING

THE cutting removed 42 per cent of the timber. Most of the trees cut were between 80 and 85 years of age. The largest trees left are estimated to be of the same age as those cut. Cordwood has been cut from the tops of the trees removed for lumber and from defective or undesirable trees too small for lumber. Compare with Plate 41, which shows the same stand before the cutting.

Saltonstall, Compartment 37.
November, 1929.

PLATE 43. WHITEWOOD LEFT TO SEED UP A SMALL OPENING

A WHITEWOOD 13 inches in diameter and 90 feet in height left on the edge of an opening after a selection cutting. About 2,400 feet, board measure, were cut per acre and 4,000 left.

North Madison, Compartment 28.
1929.

PLATE 44. A SELECTION CUTTING SHOWING THE CORDWOOD CUT FROM THE TOPS

THERE was no marking of small defective trees on this area. The white oak in the foreground, calipered, measures 12 inches in diameter. The axe is stuck in a 12-inch stump of a black oak taken out in the cutting. The stand is composed of black, white, red, and chestnut oaks, hard maple, hickory, ash, beech, and black birch. The best trees are 70 feet in height. This area is excellent soil in the foreground and grades to medium quality in the middle. Several of the trees cut were over 80 years of age. The selection cutting removed 4,200 feet, board measure, and 2 cords per acre. The remaining stand contains 3,300 feet, board measure, and 5 cords per acre.

North Madison, Compartment 24.
February, 1929.

PLATE 45. HEMLOCK SPREADING INTO THE HARDWOOD TYPE

This area is changing from hardwood to the hemlock-hardwood type by the natural seeding in of hemlock. It was cut over in 1914 to remove the chestnut. Chestnut at that time formed a heavy stand but was dying of the chestnut blight. After the cutting there remained a stand of oak which had previously been overtopped by the chestnut. The forest had closed together well and required a thinning. This was completed in the fall of 1928. Ten cords of wood were cut per acre. The remaining stand is 50 to 55 years of age and contains 4,800 feet, board measure, of lumber and 5 cords per acre. Brush will be left as it lies. A heavy undergrowth of laurel has developed luxuriantly since the chestnut died. The hemlock understory is slowly developing. This eventually will result in killing the laurel. The principal species in the stand are chestnut oak, white oak, scarlet oak, red oak, and red maple. Most of the red maple was removed in the thinnings.

Saltonstall, Compartment 21.
January, 1929.

PLATE 46. HARDWOOD REVERTING TO THE HEMLOCK-HARDWOOD TYPE

An evenaged stand of red oak, whitewood, white oak, ash, and maple, with a partial understory of hemlock. This stand was thinned in 1927, removing 9 cords of fuelwood per acre. The age of the stand at the time of the thinning was 50 years. In the immediate foreground the site is Quality 1, rather moist. This verges into well-drained land in the center of the picture. The tree in the foreground is 12 inches in diameter and 60 to 65 feet high. The present stand contains 4,500 feet, board measure, and 5 cords of wood per acre.

Saltonstall, Compartment 21.
January, 1929.

PLATE 47. HEMLOCK-HARDWOOD THINNED THREE TIMES

An evenaged stand of whitewood, oaks, white ash, beech, and maple 60 years of age, with an understory of hemlock. Three cuttings have been made on this area in the last twenty years removing 22 cords of fuelwood per acre having a stumpage value of $27 per acre. The present stand is worth $40 per acre on the stump. It is growing timber fast; and much faster than would be the case if the investment in standing timber were removed.

The picture is taken on permanent sample plot 9. The whitewood tree in the center is now 11 inches in diameter. This tree grew 3 inches in diameter in the period 1917–1926.

Saltonstall, Compartment 22.
January, 1929.

PLATE 48. AN EXCELLENT MIXTURE OF HEMLOCK AND HARDWOODS

An unevenaged forest of oak, ash, maple, and hemlock on the rocky slope of Saltonstall ridge. A cutting for timber removing the oldest and largest trees has recently been made. The cut was approximately 2,700 feet, board measure, and 13 cords per acre. The tops of trees cut for timber as well as other poor individuals have been put into cordwood. The cutting netted approximately $33 an acre and there is left invested in the standing trees a stumpage value of about $42 per acre. The remaining stand is estimated to contain 4,800 feet, board measure, and 4 cords of wood per acre. The tree with the calipers is a red oak 13 inches in diameter. Note that the slash has all been left as seen in the foreground. The trees cut ranged in age from 70 to 125 years. Those left are probably between 30 and 100 years.

The policy here is to maintain continuously a forest of the same general appearance as shown in the picture, making a cutting every fifteen years.

Saltonstall, Compartment 26.
January, 1929.

PLATE 49. A SELECTION FOREST OF HEMLOCK AND HARDWOODS

THE two large hardwoods shown in the picture are red oaks 11 and 13 inches in diameter and 60 to 70 feet in height. A cutting was made in 1923 removing the largest timber and creating an opening 30 by 60 feet in size. The stump of a 20-inch hemlock 125 years of age is shown in the right foreground. Most of the reproduction on the area is hemlock, with a sprinkling of oak, black birch, and maple. It is a site of medium quality on a north slope of talus rock. Another cutting will be made about fifteen years after the last cut. The present volume is 5,900 feet, board measure, of hemlock and 700 feet, board measure, of hardwood per acre. About 3,400 feet, board measure, per acre were cut in 1923.

Saltonstall, Compartment 28.
February, 1929.

PLATE 50. A SINGLE TREE SELECTION CUTTING IN THE HEMLOCK-HARDWOOD TYPE

In this particular spot the stand is almost entirely hemlock. The large tree in the center was removed in 1927. This tree was 125 years of age and 27 inches in diameter inside bark on the stump. The surrounding timber ranges from 30 to 100 years of age. The picture was taken in a stand being handled on the group selection method. Where occasion offered, as here, this was modified to the removal of single mature trees. It is expected that this opening will seed in with hemlock and light-seeded hardwoods. Volume left after cutting is 8,600 feet, board measure, per acre.

Saltonstall, Compartment 26.
January, 1929.

PLATE 51. HEMLOCK-HARDWOOD TYPE WITH HEMLOCK IN THE DOMINANT COVER

An unevenaged stand near the top of a steep southern slope. This stand received a selection cutting in 1927. A number of trees were removed from the area shown in the picture. The trees cut ranged in age from 70 to over 100 years. Most of the trees left are less than 50 years of age. Exceptions occur, such as the tree by which the man is standing. This tree is 13 inches in diameter, 70 feet in height, and about 80 years of age. The amount removed in the selection cutting in Compartment 26 was 2,900 feet, board measure, and 10 cords of wood per acre. The present stand is 3,200 feet, board measure, and 4 cords per acre.

Saltonstall, Compartment 26.
February, 1929.

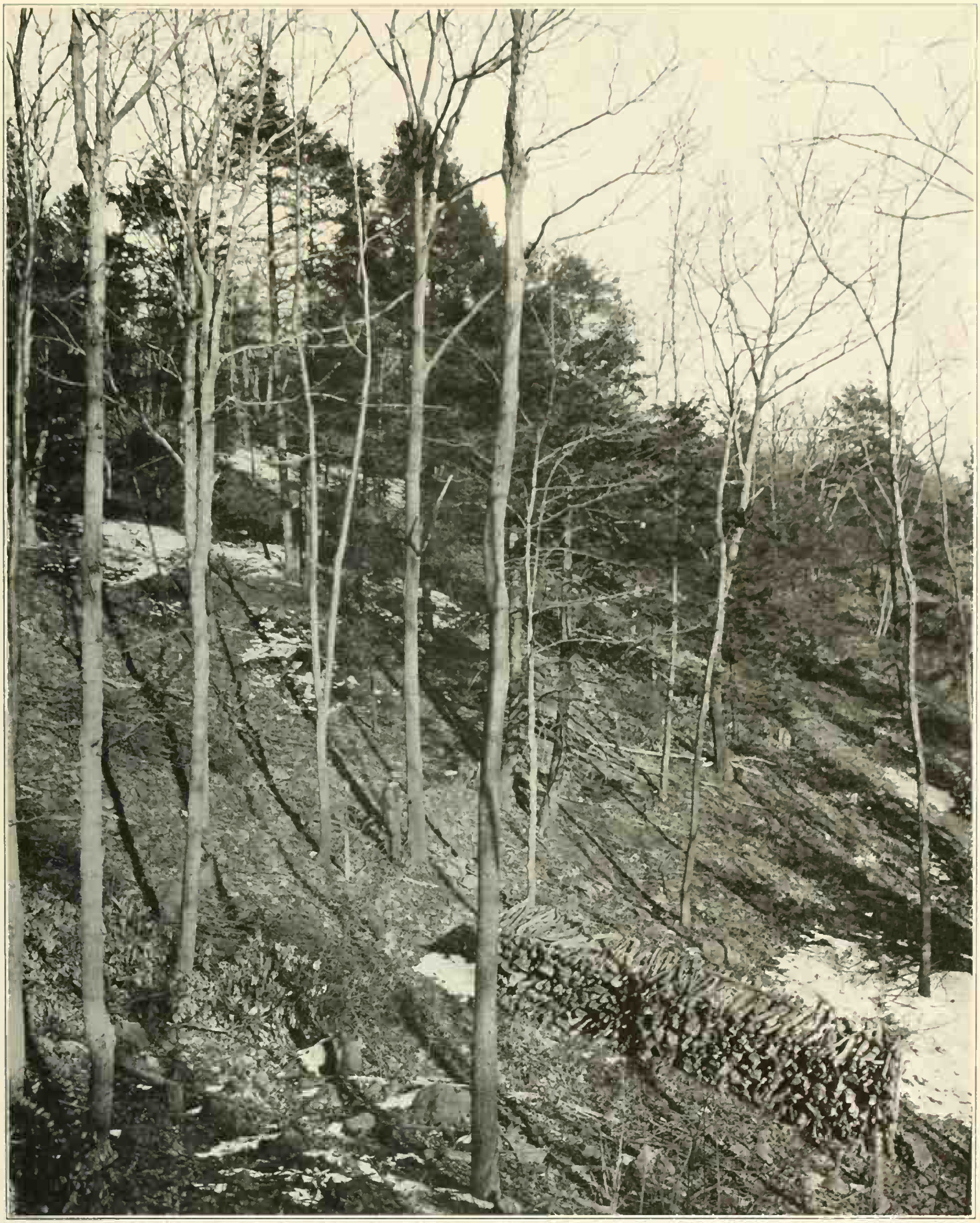

PLATE 52. RELEASE CUTTING TO FREE PINE—BEFORE THE OPERATION

In the center is shown a red pine badly in need of a release cutting. Beside the red pine is a white oak seedling indicated by the caliper, which also needs release. The prominent hardwood trees in the foreground are hard maples and hickories. These, together with some other hardwoods, principally gray birch and cherry, must be removed to free the pine and white oak. The white oak by the caliper is 10 feet high and approximately 2 inches in diameter. The red pine in the center is 7 feet in height, and the hard maple in the middle is 12 feet in height, while the two biggest hickories are 10 and 11 feet in height. The gray birch ranges from 8 to 12 feet. The age of the pine is 15 years, and the hardwoods are at least three years younger. A previous release cutting had been made several years ago.

The inferior overtopping hardwoods will be cut immediately. The same view after the cutting can be seen in Plate 53.

West River, Compartment 6.
February, 1929.

PLATE 53. RELEASE CUTTING TO FREE PINE—AFTER THE OPERATION

The same view as Plate 52, but after the release cutting has been made. The hardwoods which still appear are all well away from the pine or else are shorter than the pine, so that they do not threaten to overtop the latter. The red pine will come up beside the white oak. There should be room for both of them. Approximately one dozen trees have been cut to help the white oak and red pine. The difference in growth which occurs when the pine is not interfered with is indicated by the red pines at the right which have developed without suppression.

West River, Compartment 6.
February, 1929.

PLATE 54. RED PINE IN NEED OF PRUNING

The interior of a red pine plantation showing how persistent are the branches on planted red pine. This plantation was made in the spring of 1915 with 3-year-old transplants on a meadow of good soil. The original spacing was 6 x 6 feet. At present 1,088 trees per acre are living. The tree in the foreground is 5 inches in diameter. All the branches are dead from the ground up to and including the third whorl above the calipers. As can be seen, many of these dead branches still retain their needles and are not as yet brittle. It is believed that red pine in plantations must be pruned if a butt log of good quality lumber is to be secured within a reasonable time. The trees surrounding the central tree were pruned of their lower branches before taking the picture in order to bring out more clearly the character of the branches on the central tree. The total height of this red pine is 21 feet.

Maltby, Compartment 36.
January, 1929.

PLATE 55. THE RESULTS OF AFFORESTATION

This forest of white pine was planted nineteen years ago on a brushy field. The best trees, of which the individual in the foreground is an example, are 9 inches in diameter and 35 feet high. A considerable amount has been invested in this plantation in planting the trees, protecting them from fire, insects, and fungi, in removing shrubs and inferior species of trees which threatened to overtop and smother the newly planted pines, and in pruning the lower limbs from 150 per acre of the best individuals selected for the final timber crop. The lower seven whorls of branches were pruned in December, 1927, and two more whorls were taken off in January, 1929. The pruning is now finished, as a butt log of more than 17 feet is free of branches.

In August 60 pine trees per acre were sold, netting $15. The axe in the foreground shows the location of one of the trees removed. From this age on it is expected that receipts from thinning the plantation should exceed all expenditures. In thirty years the value of the standing timber should be at least $400 per acre. This estimate is based on present prices, without allowance for appreciation in stumpage prices. The dead branches seen on the ground will be allowed to decay as they lie for the purpose of increasing soil fertility.

Saltonstall, Compartment 8.
January, 1929.

PLATE 56. THINNING IN A WHITE PINE PLANTATION

This white pine plantation has just received a thinning. It was planted in 1913. The tree in the foreground is 5 inches in diameter. Heights range from 20 feet to 30 feet. Four cords per acre were removed in this thinning. Note the green slash on the ground. This is all that is left after cutting out wood to approximately two inches. Nothing will be done with the slash. While the trees all appear to have been pruned, most of them were so treated simply by knocking off the dead limbs with an axe in order to facilitate the thinning. There are, however, selected pruned trees such as the one in the right foreground which will be pruned up to 17 feet above the ground in order to produce a clear butt log. This pruning is done with a saw. Either this year or next year the pruning will be carried up to the full height of 17 feet. At the time of first pruning there were 862 trees per acre, and 224 of these were pruned. In making the thinning the principle of a low thinning was followed in general, but was varied sufficiently to make possible the removal of dominant and codominant trees badly affected by the white pine weevil. This stand was treated from early youth by having the weeviled leaders cut out each year and burned. The consequence is that relatively few trees were badly weeviled, and after this thinning trees which will have at least 17 feet of clear log will form the bulk of the stand. The soil is of excellent quality.

Maltby, Compartment 20.
February, 1929.

BULLETINS

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*3.—A Working Plan for the Woodlands of the New Haven Water Company, by Ralph C. Hawley. 1913.

4.—The Keene Forest—A Preliminary Report, by James W. Toumey and Ralph C. Hawley. 1916.

5.—The Den—A Preliminary Report, with Map, of a Tract of Woodland Given to the School by Mr. and Mrs. Winthrop Perry, by James W. Toumey and Ralph C. Hawley. 1920.

*6.—Lignum-vitae—A Study of the Woods of the Zygophyllaceae with Reference to the True Lignum-vitae of Commerce, by Samuel J. Record. 1921.

*7.—A Progress Report of the Results Secured in Treating Pure White Pine Stands on Experimental Plots at Keene, New Hampshire, by Ralph C. Hawley. 1922.

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